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"STUDY ME."



"I am fearfully and wonderfully made."

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(SCHOOL EDITION.)

HUMAN AND COMPARATIVE

ANATOMY,

PHYSIOLOGY, AND HYGIENE.

BY

MRS. EUNICE P. CUTTER.

WITH ONE HUNDRED ENGRAVINGS.

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PREFACE.

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THIS small manual is designed for pupils of that maturity of mind at which they can profitably pursue the study of primary arithmetic, geography, or grammar. Indeed, it can be used before geography or grammar, as it is the simpler and more interesting study.

Its object is twofold: 1. To teach the child something of the general structure of man and animals, with the use of the different parts, and to suggest *practical hints* relative to the *preservation* of health. 2. To indicate a method of *instruction*. Instruction includes *reading*, *study*, and *teaching*. Since *profitable reading* and *study* require the same analysis and method as *clear* and *efficient teaching*, therefore text books should be so arranged as to afford readers, pupils, and teachers an index to the unfolding and the necessary aid to the understanding of the subject.

TO PUPILS.

Since methods of study and preparation for recitation are important, we would suggest the following: 1. Carefully read the lesson, and commit to memory the definitions of important names or terms. 2. Compare the text with illustrating diagrams, to which reference is made. 3. Obtain and use appropriate material for illustrations in connection with the text and diagrams. 4. Draw the illustrating diagrams upon paper, slate, or black-board. 5. If able to write, commit to paper, plainly and concisely, the ideas of the lesson in your own language, without the aid of the book.

TO TEACHERS.

It is the office of the teacher to *educate*. This is done by *recitations* and by *general exercises*.

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RECITATIONS.

The objects of a *recitation* are to review the previous lesson, to determine if pupils comprehend the general principles of the present lesson and its details, to correct errors, to suggest new principles and their application, to communicate new facts, to excite observation, to induce thought, to develop expression, to cultivate the taste, to direct the imagination, to invigorate the memory, to strengthen the judgment, and to expand the soul.

To accomplish these objects, we would suggest the following method: 1. Have the previous lesson reviewed by concise oral or written abstracts, aided by a synthetic tableau upon the blackboard. 2. Have the leading topics of the present lesson stated, using appropriate illustrating material. 3. Have other principles and facts explained by the use of outline diagrams. 4. Have the lesson still further elucidated by analytic tableaux of the text upon the blackboard, and also by drawing the illustrating diagrams. 5. Examine the class in detail, and require each pupil to propose pertinent questions. 6. Have the pupils present concise oral synopses of the entire lesson and its illustrations. 7. The teacher should give a general analysis or method for the study of the next lesson, and also communicate to the class such additional principles and facts as are essential to the understanding of the subject.

GENERAL EXERCISES.

These are valuable once or twice each week. The whole school should participate in them. The following is a method for conducting a session: Let each pupil have a text book, and be required to carefully read the lesson previous to the exercise. The teacher should *analyze* and *explain* the subject, and, in an oral, familiar lecture, communicate additional principles, facts, and illustrations. This may be followed by questions to the members of the school, and by oral synopses of the lesson and lecture *from* the pupils, accompanied by questions.

To the candid examination of teachers and guardians of youth this work is respectfully submitted.

E. P. CUTTER.

WARREN, MASSACHUSETTS, November 1, 1854.

HUMAN AND COMPARATIVE ANATOMY, PHYSIOLOGY, AND HYGIENE.

INTRODUCTION.

1. HOWEVER complete a machine of human invention, none can be more perfect in structure, beautiful in appearance, or harmonious in action than the "house we live in," which is framed and furnished by the Great Architect, God.

Q. What is said of the machines made by man, compared with the "house we live in" ?

2. A watch contains beautiful wheels as well as delicate springs, all of which are surrounded by well-fitted cases. Yet the body contains parts more beautiful, organs more delicate, enclosed in cases more perfect in construction.

Q. How does a watch compare with the body, in beauty, delicacy, and perfection ?

3. Look at a watch, how beautiful soever its face, it cannot compare in loveliness with the smile that plays upon the infant's cheek. The hands of a watch tell the hour of day ; but they have no sensation or feeling like the hands of a child.

Q. What 's said of the face and hands of a watch and those of a child ?

4. The wheels of a watch move regularly ; but the click, click, is no more regular, nor more varied, than the movements of the parts of the human body.

Q. What is said of the movements of a watch, compared with those of the human body ?

5. The watch has not within itself the power of making or applying the oil necessary for its movable parts ; but God in his goodness has so made the parts of the human body that they make and apply as they need their own oily fluid.

Q. What is said of the oil needful for a watch ? How are the joints of the body oiled ?

6. The form and size of a watch do not of themselves change ; but man varies in form and size from his cradle to his grave. Growth and decay are constant in the human frame.

Q. What is said of the form and size of a watch and that of man ? What are constant in the human body ?

7. If a watch is injured, it has not power to repair or mend itself. Not so with the human body : you may bruise it, and the injured part possesses a power that is generally able to heal it.

Q. Can a watch mend or heal itself ? How is the body repaired when bruised ?

8. To understand the structure or use of a machine, it is necessary to examine the different parts separately as well as combined. The same is true of the body, which is so " fearfully and wonderfully made."

Q. What is necessary in order to understand the structure and use of a machine or the human body ?

9. For convenience, we shall divide the body into *ap-pa-ra'tus-es*, *sys'tems*, and *or'gans*.

Q. What are the general divisions of the body?

10. An APPARATUS is an assemblage of parts provided as means to an end; as, the furniture of a house.

Q. Define apparatus. Give an example.

11. A SYSTEM is an assemblage of organs or parts adjusted into a regular whole; as, the railroads of a state or country, or the organs of digestion.

Q. Define system. Give an example.

12. An ORGAN is a part or structure in which some work or process is carried on; as, a railroad locomotive or the stomach of man.

Q. Define organ. Give an example.

13. A description of the structure of man, animals, birds, or plants is called *A-nat'o-my*.

Q. What is anatomy?

14. A description of the uses of the parts of man, birds, fishes, &c. is called *Phys-i-ol'o-gy*.

Q. What is physiology?

15. A statement of the conditions upon which the health of man, animals, and plants depends is called *Hy-gi-ene'*.

Q. What is hygiene?

16. HUMAN Anatomy, Physiology, and Hygiene treat of man: *Comparative*, of other animals than man, and also of birds, fishes, and plants.

Q. What is human anatomy, physiology, and hygiene? What is comparative?

Review. — Give the comparisons and definitions of the terms in this chapter.

GENERAL ANALYSIS. *

17. The POSITION of the principal organs of the body is as easily learned as the location of cities or towns. The former is far more interesting and important than the latter.

Q. What is said of learning the position of the parts of the body?

18. The BODY has two great cavities — a *lower* and an *upper*. (Fig. 2.)

Q. Into how many great cavities is the body divided?

19. The inferior animals, as the ox and horse, also birds and fishes, have two cavities which enclose organs similar to those in the human body.

Q. What is said of the cavities of birds, fishes, and the inferior animals?

20. The LOWER cavity comprises the *mouth*, the *tho'rax*, (chest,) and the *ab-do'men*. (Figs. 2, 3.)

Q. What does the lower cavity contain?

21. The MOUTH contains the teeth and *sal'i-va-ry* glands. (Figs. 2, 3.)

Q. What does the mouth contain?

22. The THORAX contains the lungs and heart. (Figs. 2, 3.)

Q. What does the thorax contain?

23. The ABDOMEN contains the stomach, liver, *pan'-cre-as*, (sweetbread,) spleen, (milt,) small and large intestine, and kidneys. (Figs. 2, 3.)

Q. What does the abdomen contain?

* Illustrate this lesson by fishes, diagrams, drawings, and analytical tableaux on the blackboard.

Fig. 2.

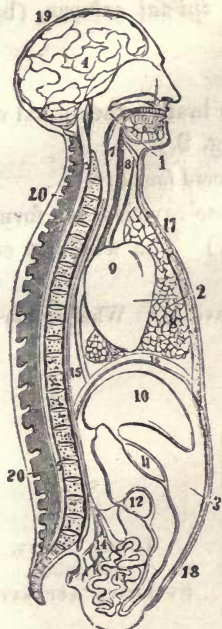


Fig. 3.

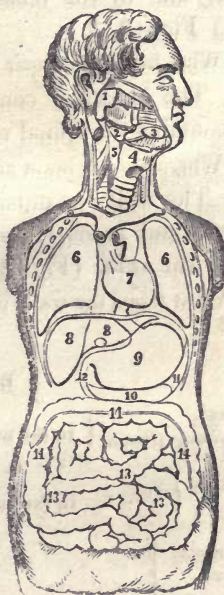


Fig. 2 represents the two great cavities of the body and their organs. 1, 2, 3. The lower cavity. 1. The mouth. 2. The thorax. 3. The abdomen. 6. A salivary gland. 7. The œsophagus. 8, 8. The trachea and lungs. 9. The heart. 10. The liver. 11. The stomach. 12. The colon. 13. The small intestine. 14. The lacteals. 15. The thoracic duct. 16. The diaphragm. 17, 18, 20, 20. The walls of the lower cavity, composed of bones, muscles, and skin.

4, 5, 5. The upper cavity and its organs. 4. The brain. 5, 5. The spinal cord. 19, 20, 20. The walls of the upper cavity. 19. The cranium. 20, 20. The spinal column.

Fig. 3 represents the position of the organs of the mouth, thorax, and abdomen. 1, 2, 3. Salivary glands. 4. The larynx and trachea. 5. The œsophagus. 6, 6. The lungs. 7. The heart. 8, 8. The liver. 9. The stomach. 10. The pancreas. 11. The spleen. 12. The duodenum. 13, 13, 13. The small intestine. 14, 14, 14. The large intestine.

24. The UPPER cavity is formed by the *crā'ni-um*, (skull,) and by the bones of the *spi'nal col'umn*, (back bone.) Figs. 2, 3.)

Q. What forms the upper cavity ?

25. The CRANIUM contains the brain ; the spinal column contains the spinal cord. (Fig. 2.)

Q. Where are the brain and spinal cord found ?

26. The walls, or outside of these cavities, are formed by *bones* and *muscles*, (lean meat.) The whole is covered by the *skin*. (Figs. 2, 3.)

Q. What forms the walls of these cavities ? What covers the whole ?

REVIEW.

21. <i>Teeth,</i> <i>Salivary Glands,</i>	}	In the MOUTH.	}	LOWER CAVITY, containing NUTRITIVE APPARATUS.		
22. <i>Lungs,</i> <i>Heart,</i>					} . . .	In the THORAX.
23. <i>Stomach,</i> <i>Liver,</i> <i>Pancreas,</i> <i>Spleen,</i> <i>Intestines,</i> <i>Kidneys,</i>	} . .	In the ABDOMEN.				
25. <i>Brain,</i> <i>Spinal Cord,</i>					} . {	In the SKULL and SPINAL COLUMN.
26. <i>Bones,</i> <i>Muscles,</i> <i>Skin,</i>						

Review by Questions. — What can you state of the cavities of the body of man ? of animals ? of birds ? of fishes ? What do these cavities contain ? What forms the walls of these cavities ?

REVIEW BY TOPICS. — Give the general analysis of the human system, and that of animals, birds, and fishes. (See outline anatomical, Plates V and VIII.)

PART I.

27. IN this part the NUTRITIVE APPARATUS will be described. This embraces the *di-ges'tive, re-spi'ra-to-ry,* and *cir'cu-la-to-ry* systems, or the "builders up" and "pullers down" of the body. (Figs. 2, 3.)

Q. What systems are classed under the nutritive apparatus?

CHAPTER I.

28. The DIGESTIVE SYSTEM will be described in this chapter. It embraces the *teeth, sal'i-va-ry glands, stom'ach, small in-tes'tine, liver, pan'cre-as, (sweetbread,) lac'te-als,* and *large in-tes'tine.* (Figs. 2, 3, 20.)

Q. How is the digestive system divided?

LESSON I.

29. In a flouring mill there are burr stones. By the rapid motion of one stone upon the other, wheat and other grains are crushed and made fine; so the *teeth*, by the movement of the lower upon the upper jaw, cut, crush, and make fine the solid part of the food.

Q. To what may the teeth be compared? What is the use of the teeth?

TEETH.*

30. The TEETH are connected with the jaw by the *sockets*, (al-ve'o-lar processes.)

Q. How are the teeth connected with the jaw?

31. The SOCKETS are covered, and the neck of the tooth is surrounded, by a firm membrane called *gum*.

Q. What is the gum?

Fig. 4.

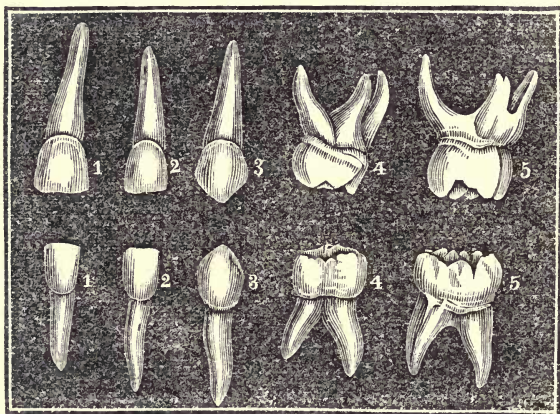


Fig. 4 represents the milk teeth from the left side of the jaw. 1, 2 Cutting teeth, (incisors.) 3. Eye tooth, (cuspid.) 4, 5. Grinders. (molars.)

32. Children have twenty teeth, which are called the

* To illustrate this lesson, use the jaws and teeth of different animals; as the ox, horse, squirrel, as well as man, with drawings upon the blackboard. (See *Preface*.)

milk teeth. These are generally removed before the child is eight years old. (Fig. 4.)

Q. How many teeth has the child? What are they called? When are they removed?

Observation. — Calves, lambs, and colts have milk teeth, that are removed early like human teeth.

Q. What is said of the milk teeth of calves, lambs, &c.

33. The adult or fullgrown person has thirty-two, called *permanent teeth.* (Fig. 5.)

Q. How many teeth has a fullgrown person? What are they called?

Fig. 5.

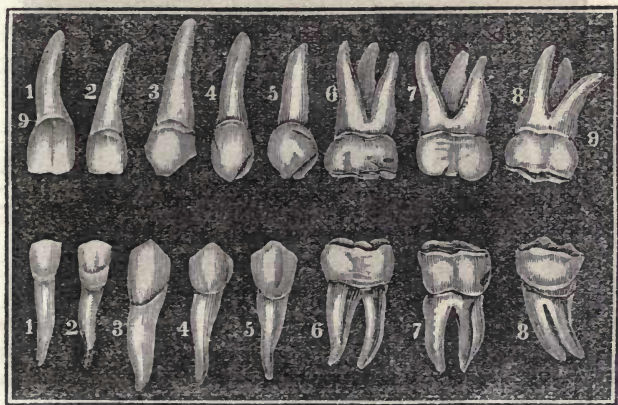


Fig. 5 represents the adult teeth. 1, 2. The cutting teeth, (incisors.) 3. Eye tooth, (cuspid.) 4, 5. Small grinders, (bicuspids.) 6, 7, 8. Grinders, (molars.) 9, 9. Neck of the tooth.

34. The front teeth that cut or divide the food are called *in-ci'sors*, (cutting teeth.) Those that crush or grind the food *mo'lars*, (grinding teeth.) (Fig. 5.)

Q. What are the front teeth called? Those that crush the food?

35. The part of the tooth above the jaw is called the *crown*, the portion in the jaw the *root*. The neck of the tooth is where the root and crown unite. (Fig. 5.)

Q. What part of the tooth is called the crown? The root? The neck?

36. The CROWN of the tooth contains *i'vo-ry*, or bone, and a still harder substance, called *en-am'el*. The root has no enamel. (Figs. 6, 7, 8.)

Q. What does the crown of the tooth contain? How does the root differ from the crown?

Fig. 7.

Fig. 6.

Fig. 8.

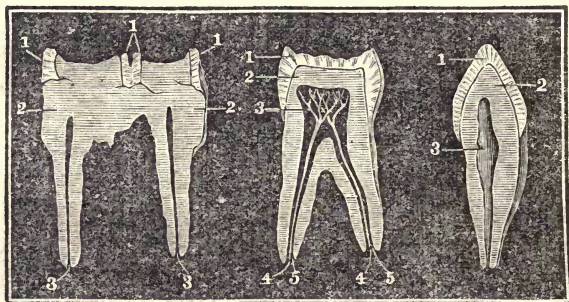


Fig. 6. A section of a molar tooth of man. 1. The enamel. 2. The ivory. 3. The cavity containing blood vessels. 4, 5. Artery and nerve.

Fig. 7. Section of the molar tooth of a horse. 1. The enamel. 2. The ivory. 3. Canal for blood vessels.

Fig. 8. Section of molar tooth of a dog. 1. The enamel. 2. The ivory. 3. Cavity for blood vessels.

37. The ENAMEL in man covers the entire crown of the tooth. (Fig. 6.) In the horse, the enamel surrounds, but does not cover, the upper surface of the crown, while plates of it exist in the central parts of the tooth. (Fig. 7.) In the teeth of animals that feed upon flesh,

as the dog, cat, and lion, the enamel covers the cutting edges of the crown. (Fig. 8.) In the gnawing or front teeth of squirrels, rats, and rabbits, the enamel is only upon the front surface. (Fig. 11.)

Q. Where is the enamel of the tooth in man? The horse? The dog? The squirrel?

Observation. — By the arrangement of the enamel, the grinding teeth of the horse and ox are always uneven, like a millstone, while the front teeth of a squirrel are sharp. For this reason he can chisel a hole so quickly in his stolen nut, while the horse and ox easily grind grains and grasses. The large teeth of animals that feed on flesh, as the cat, dog, and lion, by the form of the crown and arrangement of the enamel, are sharp, and cut like the blades of shears.

Q. What is said of the teeth in different animals?

Fig. 9.

Fig. 10.

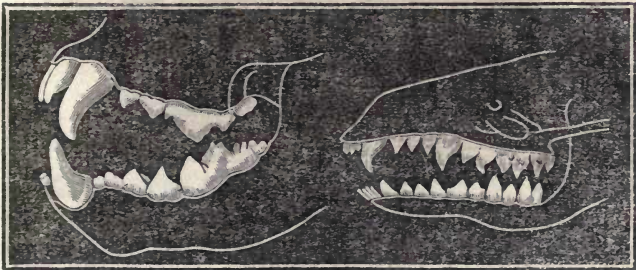


Fig. 9 represents the teeth of a flesh-eating animal.

Fig. 10 represents the teeth of an insect-eating animal.

38. In animals that live on insects the molar teeth are raised into conical points, which lock into depressions in the teeth of the opposite jaw. (Fig. 10.)

Q. How are the teeth arranged in animals that eat insects?

39. The movement of the lower jaw varies in different animals. In flesh-eating animals, as the cat and lion, the movement is hingelike, and the molar teeth are cutting instruments like shears. In the ox and horse the movement is lateral, and the molar teeth are grinding instruments like a millstone. In gnawing animals the movement is backward and forward, with no lateral motion. In man we find a moderate degree of the three movements — cutting, grinding, and gnawing.

Q. What is the movement of the jaws in flesh-eating animals? In grain eating? In gnawing? In man?

Remark. — Observe the movements of the lower jaw in man, the cat, squirrel, and horse, to illustrate this paragraph.

Fig. 11.

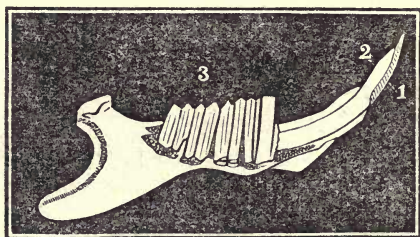


Fig. 11. Lower jaw of a squirrel. 1. The enamel of the gnawing tooth. 2. The ivory. 3. The lateral furrows of the molar teeth.

40. The molar teeth of squirrels, rabbits, and rats have lateral furrows upon the crown, so that the forward and backward movement of the jaws grinds the food as perfectly as the lateral motion of the jaws of a horse. (Fig. 11.)

Q. How are the molar teeth of squirrels furrowed? What is the effect of this in grinding food?

41. To prevent the teeth from decaying, they must be kept clean. The teeth and gums should be cleaned by using a soft brush and water after every meal; also before going to bed and after rising in the morning.

Q. Why must the teeth be kept clean? How should they be cleaned? How often?

42. The teeth should not be used to crack nuts, bite threads, or picked with pins. Ivory or quill tooth-picks should be used.

Q. For what purposes should the teeth not be used?

REVIEW.

30, 31, 32, 33, 34, 35, 36, 37, 38, 40.	<i>Anatomy</i>	} of the TEETH.
29, 34, 37, 38, 39, 40.	<i>Physiology</i>	
41, 42.	<i>Hygiene</i>	

Review by Questions. — What can you say of the structure of the human teeth? of the teeth of animals? What can you tell of the use of the teeth in man? in animals? What can you relate of the movement of the jaws in animals? in man? How may the teeth be preserved?

REVIEW BY TOPICS. — Give the Anatomy of the teeth, human and comparative, the Physiology, the Hygiene.

LESSON II.

43. To make a solid or dry substance soft, or pulpy, as making flour into dough, it must be mixed with water or some other fluid. So the solid food, as meat or dry biscuit, when divided by the teeth, needs some fluid to fit it for swallowing. Hence the Author of our being has placed some little bodies about the mouth that supply a fluid. These bodies are called *salivary glands*.

Q. What is necessary after solid food is divided by the teeth? What are the bodies called that supply this fluid?

SALIVARY GLANDS.*

44. The SALIVARY GLANDS are six in number, three on each side of the face. (Figs. 12, 13.) The fluid that flows from them into the mouth is called *sa-li'va*. The common name is *spittle*.

Q. How many salivary glands are there? What is the name of the fluid that flows from them?

Fig. 12.

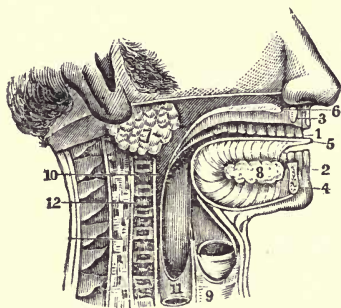


Fig. 13.

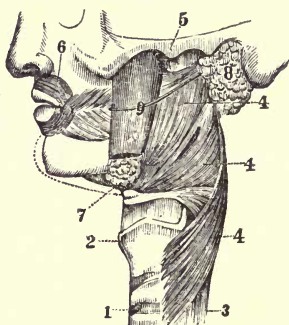


Fig. 12. The mouth laid open. 1. The teeth. 3, 4. Upper and lower jaws. 5. The tongue. 7, 8. Salivary glands. 9. Trachea, (wind-pipe.) 10, 11. Œsophagus, (gullet.) 12. Spinal Column.

Fig. 13. A side view of face. 1, 2. Trachea. 3, 4. Œsophagus. 7, 8. Salivary glands. 9. Duct from the parotid gland. 4, 5, 6. Muscles.

Observation.—The largest of these glands, (called parotid,) which lies under the ear, is enlarged in the disease called *mumps*. (Figs. 12, 13.)

Q. What gland is diseased in mumps?

* Illustrate this lesson by using similar parts of animals, outline plates, the blackboard, and experiments.

Experiment. — To show the use of saliva, take half a dry biscuit and reduce it to a powder ; break the remaining half into small pieces, and let several pupils hold a piece in the mouth until moist and soft ; and the effect of saliva upon food will be shown by comparing the pulp with the powdered biscuit.

Q. How can the effects of saliva upon solid food be shown ?

45. In health, we need not drink while eating or while speaking. The flow of saliva is generally sufficient to moisten both the food and the mouth. We may drink moderately after eating.

Q. Is it necessary to drink while eating or speaking ? When may we drink ?

46. It is not healthy to chew gums, tobacco, or any hard substance, as they cause a great flow of saliva. The habit of frequent spitting is also injurious to health.

Q. Is it healthy to chew gums or tobacco ? What is said of frequent spitting ?

47. The food, after it is chewed and mixed with saliva, is carried from the back side of the mouth through a tube to the stomach. The name of this tube is *æ-soph'-a-gus*, (gullet.) (Figs. 12, 13.)

Q. What becomes of the food after it is mixed with saliva ? What is the name of this tube ?

Remark. — Use the *æ-sophagus* of the sheep, calf, or ox to illustrate this tube in man.

REVIEW.

44, 47.	<i>Anatomy</i>	} of the SALIVARY GLANDS.
43, 44, 47.	<i>Physiology</i>	
45, 46.	<i>Hygiene</i>	

Review by Questions. — What can you say of the salivary glands ? of the saliva ? of spitting ? of chewing gums and tobacco ? of drinking ? of swallowing ?

REVIEW BY TOPICS. — State the Anatomy of the salivary glands and *æ-sophagus*, the Physiology, the Hygiene. (See outline anatomical, Plate V.)

LESSON III.

48. In preparing some articles for food, we add more than one kind of fluid ; so the pulpy mass that has passed from the mouth to the stomach needs another fluid to make it soft enough to pass through the *py-lor'ic* orifice (gatekeeper) of this organ. This fluid is supplied by the *stom'ach*. (Fig. 14.)

Q. What is necessary to render the pulpy mass in the stomach softer ?

THE STOMACH.*

49. The STOMACH is a curved, oblong sac, or pouch, situated in the left side, below the heart. It has two openings — one connected with the œsophagus, and the other connected with the small intestine. (Fig. 14.)

Q. Describe the stomach ? How many openings has it ? With what are they connected ?

50. The stomach is made up of three coats, or membranes. The outer coat (*se'rous*) is smooth and glistening. The middle coat (*mus'cu-lar*) resembles lean meat. The inner coat (*mu'cous*) is soft like velvet. In health, this coat is a delicate peach color. (Fig. 14.)

Q. Of what is the stomach composed ? What is the appearance of the outer coat ? The middle coat ? The inner coat ? Its color ?

51. In the coats of the stomach are very small bodies, called *gas'tric glands*. These supply the fluid called *gastric juice*. (Fig. 14.)

* Illustrate the general structure of the stomach by using that of a lamb, calf, fowl, or the article of food called tripe ; outline plates and the blackboard.

Q. Where are the gastric glands found? What do they supply?

52. By the action of the coats of the stomach, the food is turned over and over and mixed with the gastric juice, which changes it to a grayish paste called *chyme*. This is passed into the small intestine. (Fig. 14.)

Q. How is the food mixed with the gastric juice? What does the food become? Into what does it pass?

Observation. — The gastric juice is so powerful a solvent that it will corrode or eat silver and hardened steel.

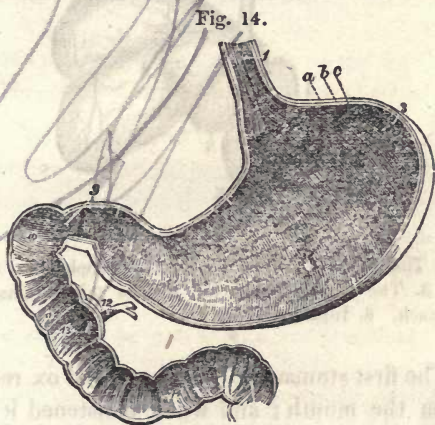


Fig. 14. Inner surface of the stomach and part of the small intestine, (duodenum.) 1. Lower part of the œsophagus. 3. The stomach. 9. The opening into the small intestine. 10, 11, 14. The duodenum. 12, 13. Ducts from the liver and pancreas. *a, b, c.* Three coats of the stomach.

53. In flesh-eating animals (*car-niv'o-rous*) the stomach is small. In grass-eating animals (*her-biv'o-rous*) the stomach is large and divided into several sacs. (Fig. 15.)

Q. What is said of the size of the stomach of flesh-eating animals? Of grass-eating animals?

54. While man has but one stomach, the sheep and ox have four. Birds have three stomachs. (Figs. 14, 15, 21.)

Q. How many stomachs have the ox and sheep? How many stomachs have birds?

Fig. 15.

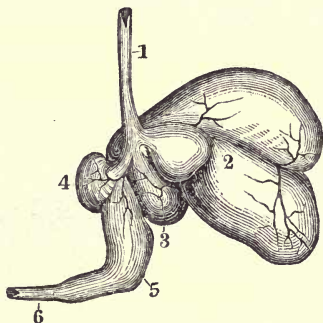


Fig. 15. The stomach of the sheep. 1. Œsophagus. 2. The first stomach. 3. The second stomach. 4. The third stomach. 5. The fourth stomach. 6. Intestine.

55. The first stomach of the sheep and ox receives the food from the mouth; and when moistened it is passed into the second stomach, from which it is raised to the mouth to be chewed. The food, or cud, is passed into the third stomach, and there it is mixed with some other fluids. From the third it is carried into the fourth stomach, and then into the intestine. (Fig. 15.)

Q. Describe the passage of food through the several stomachs of the ox and sheep.

Remark.—1. Fluids, as water, are passed directly into the second stomach of the ox and sheep. 2. Ren

net, that is used in making cheese, is the prepared stomach of the calf.

Q. Which stomach of the ox do the fluids pass into? Of what practical use is the stomach of the calf?

56. The food of birds is passed into the first stomach, (crop;) here it is moistened, and then passed into the second stomach, and becomes mixed with the gastric juice. From the second it is carried to the third stomach, (gizzard,) where it is ground, thence into the intestine. (Fig. 21.)

Q. Describe the passage of food through the stomachs of a fowl.

57. Food is needed for two objects — one for the growth of the body, the other for fuel to keep the body warm.

Q. For what two objects do we need food?

Observation. — Adult persons, if their habits are inactive, need much less food for the first object above named than is generally supposed. For the second object, more food is required in cold than in warm weather.

Q. What class of persons require but little food? In what weather do we need the most food? Why?

58. Food should be eaten at regular periods. The time between meals should vary from four to six hours.

Q. When should food be eaten? How often should we eat?

Remark. — The principles of the last-mentioned paragraphs should be observed in feeding horses and other animals.

Q. What care should we have in feeding domestic animals?

59. The stomach, like other parts of the body, when used, needs rest. For this reason, food should not be

taken between meals, particularly “nice bits” and confectionery.

Q. Why should not food be taken between meals?

60. To prevent dyspepsia, or indigestion of food, we should eat slowly and chew well the food. We should not eat when tired nor when we feel angry. Gentle exercise before and after eating, together with pleasant conversation, tends to prevent disease of the stomach.

Q. What are some of the means to prevent indigestion?

REVIEW.

49, 50, 51, 53, 54.	<i>Anatomy</i>	} of the STOMACH.
48, 51, 52, 55, 56, 57.	<i>Physiology</i>	
57, 58, 59, 60.	<i>Hygiene</i>	

Review by Questions. — What can you tell of the structure of the human stomach? of the stomach of animals? of birds? of the gastric juice? What can you state of the change of food in the stomach of man? in animals? in birds? For what is food needed? How should food be taken? How can dyspepsia be prevented?

REVIEW BY TOPICS. — Give the Anatomy of the stomach, human and comparative, the Physiology, the Hygiene. (See outline anatomical, Plate V.)

LESSON IV.

61. To prepare some articles for diet, different processes are necessary: in order that the food we eat may nourish us, it must undergo one process or change in the mouth, another in the stomach, and still another in the *small intestine*.

Q. Are different processes necessary to fit the food to nourish us?

SMALL INTESTINE, LIVER, AND PANCREAS.*

62. The SMALL INTESTINE is a tube about twenty feet

* As the liver, pancreas, and small intestine of domestic animals and birds resemble these parts in man, obtain and use them to illustrate this lesson in connection with charts and the blackboard.

long and one inch in diameter. It is composed of coats, or membranes, like the stomach. (Figs. 16, 20.)

Q. Describe the small intestine.

63. In flesh-eating animals, as the cat and lion, and also in birds, the small intestine, compared with the length of the animal, is much shorter than in man; while in grass-eating animals, as the sheep and ox, it is much longer, compared with the length of the body, than in man.

Q. What is said of the length of the small intestine in flesh-eating animals? In grass-eating animals?

Fig. 16.

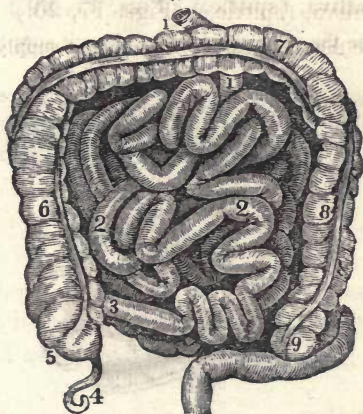


Fig. 16. 1, 2, 3. The small intestine. 5, 6, 7, 8, 9. The large intestine.

Observation. — In some animals the small intestine is not more than six feet long; while in others, as the sheep or ox, it is fifty or sixty feet.

Q. What is said in the observation in regard to the length of the intestine?

64. The upper part of the small intestine, that con-

nects with the stomach, is called the *du-o-de'num*. Here an important change of the food is effected. (Figs. 14, 16, 17, 20.)

Q. What is the upper portion of the small intestine called? What is effected in this tube?

65. The LIVER is a large organ, (gland,) situated above the duodenum and in the right side of the body. It supplies a sweetish, yellow fluid called *bile*. (Figs. 17, 20.)

Q. Describe the liver. What does it supply?

66. The PANCREAS, (sweetbread,) is a long, flattened organ, situated behind the stomach. It supplies a fluid resembling saliva, (spittle.). (Figs. 17, 20.)

Q. Describe the pancreas. What does it supply?

Fig. 17.

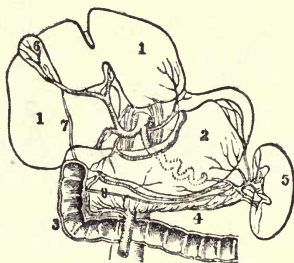


Fig. 17. 1, 1. The liver turned up. 2. The stomach. 3. The duodenum. 4. The pancreas. 5. The spleen. 6. The gall cyst. 7. The bile duct. 8. Duct from the pancreas.

67. On the under side of the liver is a small sac, (gall cyst,) that supplies a bitter, greenish fluid called *gall*. The bile and gall enter the duodenum by the

same duct. The pancreatic duct enters the duodenum near the bile duct. (Figs. 17, 20.)

Q. What is found on the under side of the liver? Name the fluids that pass into the duodenum.

Observation. — The bile flows into the duodenum, not into the stomach; hence emetics, pills, and bitters are not needed to remove it from the stomach. (Figs. 17, 20.)

Q. Why do we not need emetics and bitters to remove bile from the stomach?

68. In the duodenum, the fluids from the liver and pancreas unite with the grayish paste (*chyme*) and change it into a fluid substance called *chyle*, and into *re-sid'u-um*, (waste matter.) (Figs. 17, 20.)

Q. What effect have the fluids from the liver and pancreas upon chyme in the duodenum? Into what is it changed?

69. When a person is sick of fever, inflammation, diarrhoea, or any acute disease, food should not be taken, as it is not changed into chyme or chyle.

Q. When should a person abstain from food? Why?

Illustration. — Often little children, when faint and weak from sickness, ask for food; and the kind mother, to strengthen them, gives what she calls *harmless diet*. Too frequently it increases the pain and disease, until finally her cherished child passes from this world to its spirit home.

Q. What is said, in the illustration, of taking food?

70. When recovering from sickness, food should be taken at *regular intervals* as in health. Care should be taken that it is adapted to the *present state* of the digestive organs, in *quantity* as well as *quality*.

Q. How should food be taken when recovering from sickness? What caution is necessary?

REVIEW.

62, 63, 64, 65, 66, 67.	<i>Anatomy</i>	} of the SMALL INTESTINE, LIVER, and PANCREAS.
61, 64, 65, 66, 67, 68.	<i>Physiology</i>	
67, 69, 70.	<i>Hygiene</i>	

Review by Questions. — What can you say of the small intestine in man? in flesh-eating animals? in grass-eating animals? What can you relate of the liver? of the bile? What can you state of the pancreas? of the pancreatic fluid? What can you tell of the change of food in the small intestine? How is this change produced? What can you say of the food in sickness? when recovering from sickness?

REVIEW BY TOPICS. — State the Anatomy of the small intestine, liver and pancreas, human and comparative, the Physiology, the Hygiene. (See outline anatomical, Plate V.)

LESSON V.

71. In preparing crushed grain for bread, the meal is sifted, for the purpose of separating the waste particles (bran) from the flour. So in the human body, a set of ducts, or vessels, called *lac'te-als*, act like sieves in separating the nourishing part of the food (*chyle*) from the waste matter, (*residuum*.) (Fig. 18.)

Q. How is flour separated from the bran? How is the chyle separated from the residuum? What are these vessels called?

THE LACTEALS AND THORACIC DUCT.*

72. The LACTEALS commence in the internal coat of the small intestine. These minute vessels pass through small glands and unite and reunite with each other, until one duct is formed, called *tho-rac'ic*. (Fig. 18.)

Q. Where do the lacteals commence? Describe these vessels.

73. The THORACIC DUCT is about the size of a goose

* Illustrate this lesson by plates and the blackboard.

quill. This tube commences below the pancreas, and ascends behind the stomach, liver, and heart, between these organs and the spinal column, and opens into a vein behind the left collar bone. (Fig. 18.)

Q. What is the size of the thoracic duct? Describe its course

Fig. 18.

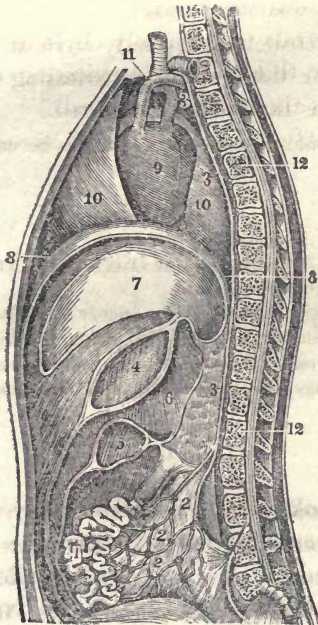


Fig. 18. 1. Small intestine. 2, 2, 2. Lacteals. 3, 3, 3. Thoracic duct. 4. Stomach. 5. Colon. 6. Pancreas. 7. Liver. 8, 8. Diaphragm. 9. Heart. 10, 10. Lungs. 11. Large vein into which the thoracic duct opens. 12, 12. Spinal column.

74. The chyle is taken up by the lacteals and con-

veyed into the thoracic duct. The waste matter is carried into the large intestine. (Figs. 18, 20.)

Q. What becomes of the chyle? Of the waste matter?

75. The chyle is carried through the thoracic duct, and is poured into a vein at the lower part of the neck, where it mixes with the blood. (Fig. 18.)

Q. Through what duct does the chyle pass? Into what is it poured? With what does it mix?

76. The lacteals take up only chyle or what has been digested. For this reason, intoxicating drinks should not be used, as they are not digested.

Q. Why should not intoxicating drinks be used?

REVIEW.

72, 73.	<i>Anatomy</i>	} of the LACTEALS and THORACIC DUCT.
71, 74, 75. . . .	<i>Physiology</i>	
76.	<i>Hygiene</i>	

Review by Questions. — What can you tell of the structure of the lacteals? of the position of the thoracic duct? What can you say of the use of each?

REVIEW BY TOPICS. — Give the Anatomy of the lacteals and thoracic duct, the Physiology, the Hygiene. (See outline anatomical, Plate V.)

LESSON VI.

77. As a cook collects from food many useless pieces, so in the economy of the body the waste matter of the food is collected in the large intestine called the *co'lon*.

Q. Where is the waste matter collected? What is this organ called?

THE LARGE INTESTINE.*

78. The COLON connects with the small intestine above

* The large intestine can be illustrated by using the corresponding part of a pig, or tripe. Outline anatomical, plates and the blackboard.

the right hip bone. It ascends and crosses under the liver and stomach, then turns downward to the left hip bone. Here the colon takes another turn backward and downward. This last portion is called the *rectum*. (Figs. 19, 20.)

Q. Describe the course of the colon. What is the last portion of the colon called ?

Fig. 19.

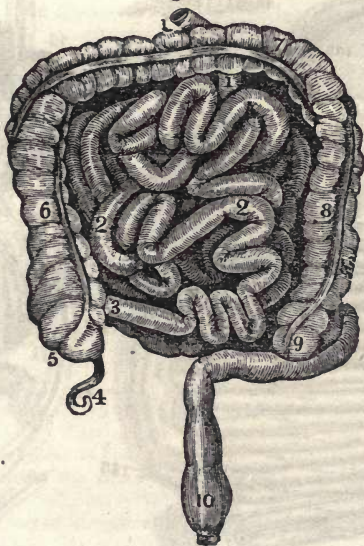


Fig. 19. The large intestine and a portion of the small intestine. 5 6, 7, 8, 9. The Colon. 10. The rectum. 2, 2, 2. Small intestine. 1, 1. The duodenum.

79. The large intestine has sacs, or pouches. This tube is shorter, though much larger in diameter, than the small intestine. (Figs. 19, 20.)

Q. What is the form and size of the large intestine ?
(See p. 36.)

Fig. 20.

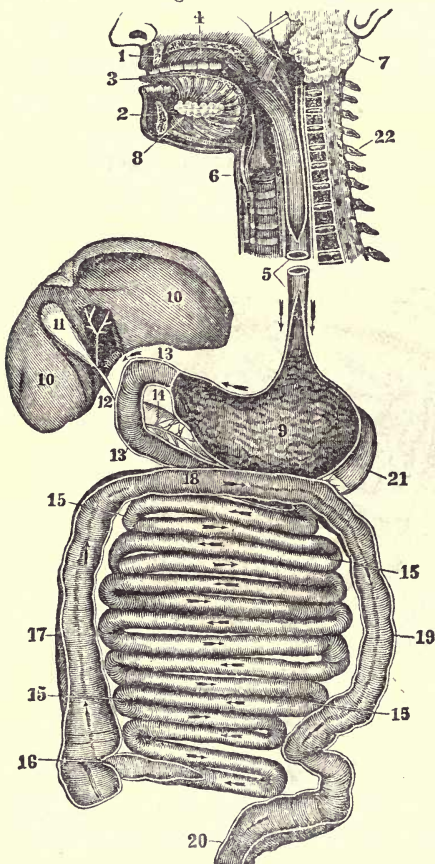


Fig. 21.

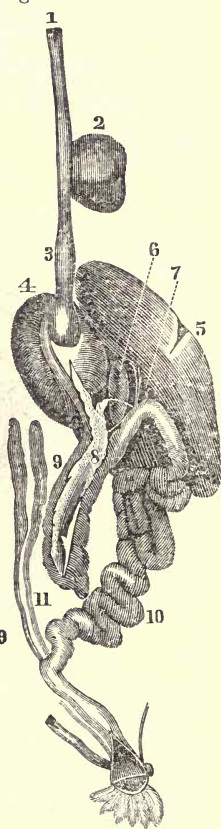


Fig. 20. An ideal view of the organs of digestion, opened nearly the whole length. 1. The upper jaw. 2. The lower jaw. 3. The tongue. 4. The roof of the mouth. 5. The œsophagus. 6. The trachea. 7. The parotid gland. 8. The sublingual gland. 9. The stomach. 10, 10. The liver. 11. The gall cyst. 12. The duct that conveys the bile to the duodenum, (13, 13.) 14. The pancreas. 15, 15, 15, 15. The small intestine. 16. The opening of the small intestine into the large intestine. 17, 18, 19, 20. The large intestine. 21. The spleen. 22. The upper part of the spinal column.

Fig. 21. Digestive apparatus of a fowl. 1. The œsophagus. 2. The crop. 3. The second stomach. 4. The gizzard. 5. The liver. 6. The gall bladder. 7. The bile ducts. 8. The pancreas. 9. The duodenum. 10. The large intestine. 11. The two cæca.

SYNTHETIC REVIEW OF THE DIGESTIVE SYSTEM.

30, 31, 32, 33, 34, 35, } 36, 37, 38, 40. . . }	Teeth,	ANATOMY	} of the DIGESTIVE SYSTEM. (Figs. 20, 21.)
44, 47, 43.	Salivary glands,		
49, 50, 51, 53, 54. . .	Stomach,		
62, 63, 64, 65, 66, 67.	Small intestine,		
72, 73.	Lacteals,		
78, 79, 80.	Large intestine,	PHYSIOLOGY	
29, 34, 37, 38, 39, 40.	Teeth,		
44, 47, 43.	Salivary glands,		
51, 52, 55, 56, 57, 48.	Stomach,		
64, 65, 66, 67, 68, 61.	Small intestine,		
74, 75, 71.	Lacteals,	HYGIENE	
81, 77.	Large intestine,		
41, 42.	Teeth,		
45, 46.	Salivary glands,		
57, 58, 59, 60. . . .	Stomach,		
67, 69, 70.	Small intestine,		
76.	Lacteals,		
81, 82, 83.	Large intestine,		

Review by Questions.—What can you tell of the structure of the teeth in man? in animals? What of the salivary glands? What of the stomach in man? in animals? in birds? What of the small intestine in man? in animals? What of the liver? What of the pancreas? What of the lacteals? of the thoracic duct? What of the large intestine?

What can you say of the use of each of the above-mentioned parts in man? in animals?

What can you relate of the manner in which food should be taken? What can you state of the means for preserving health?

REVIEW BY TOPICS.—Give the Anatomy of the digestive organs, human and comparative, the Physiology, the Hygiene. (Use outline anatomical, Plate V.)

80. The colon has three coats, or membranes, like the stomach and small intestine. (Figs. 19, 20.)

Q. How many coats has the colon?

81. The waste matter in the small intestine is passed into the colon, from which it should be discharged regularly, as well as the fluid (urine) from the kidneys. These two functions of the system should not be neglected by children or adults. (Figs. 19, 20.)

Q. Should the removal of the waste matter of the body be neglected?

82. To secure health and prevent disease, the food, exercise, and habits should be such as to produce the daily removal of waste matter from the intestine, (and it is better that it be at particular hours.)

Q. What is necessary to secure health and prevent disease?

83. When, by accident or otherwise, poisons are taken, they should be removed, or their action changed before they pass out of the stomach.

Q. What is necessary when poisons are swallowed?

Remark. — Let the teacher give oral instruction upon the antidotes for poisons and the means to remove them from the stomach.

(See First Book on Hygiene, page 170, and Anatomy, Physiology, and Hygiene, page 439, by CALVIN CUTTER, M. D.)

REVIEW.

78, 79, 80. . .	<i>Anatomy</i>	} of the LARGE INTESTINE.
77, 81. . .	<i>Physiology</i>	
81, 82, 83. . .	<i>Hygiene</i>	

Review by Questions. — What will you say of the structure of the large intestine? What can you tell of the waste matter? What can you state of habits? What can you relate of poisons?

REVIEW BY TOPICS. — Give the Anatomy of the large intestine, the Physiology, the Hygiene. (See outline anatomical, Plate V.) (Review lesson, see p. 34.)

CHAPTER II.

84. IN this chapter we shall describe the second division of the “Builders up” and “Pullers down” of the body. These are the RESPIRATORY, or breathing organs. They will be divided into four parts. 1. The *chest*, that holds the other parts. 2. The *lungs*. 3. The *blood vessels* of the lungs. 4. *Air*.

Q. Of what does the second chapter treat? How is this chapter divided?

LESSON VII.

85. The CHEST is formed of bones and muscles. These parts are so arranged and connected that the size of this cavity is varied by their movements. It also protects the lungs—those delicate organs, so necessary to life. Anatomists call it *Tho'rax*. (Fig. 32.)

Q. How is the chest formed? What organs does it protect?

THE THORAX.*

86. The THORAX is formed of the *ster'num*, (breast bone,) in front; twelve bones of the *spinal column*, (back bone,) behind; twenty-four *ribs*, twelve on each side; and the *di'a-phragm*, (midriff,) below. (Figs. 22, 32.)

Q. What parts form the thorax, or chest?

87. The RIBS are united to the sternum in front and

* Use the ribs, bones of the spine, and sternum of animals, with outline plates and the blackboard, to illustrate this lesson. See *Preface*.

to the bones of the spinal column behind. They curve somewhat like hoops of a barrel. The front part, however, is the lowest. (Fig. 22.)

Q. With what are the ribs united? What is their form?

Fig. 22.

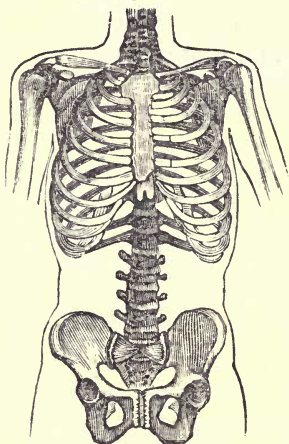


Fig. 23.

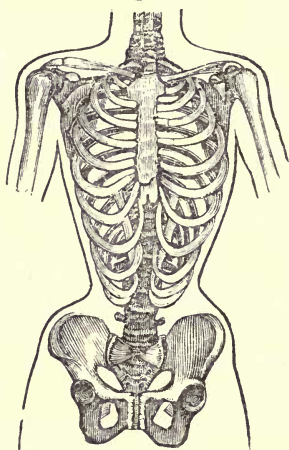


Fig. 22. A natural and well-proportioned chest.

Fig. 23. A chest fashionably deformed.

88. The upper ribs are the shortest. This gives the chest nearly the form of a sugar loaf. Hence the lower part of the chest is broadest. (Fig. 22.)

Q. What is the form of the chest? What part of the chest is the broadest?

89. The DIAPHRAGM (midriff) forms the floor of the chest. It separates the breathing organs from the stomach and liver. In form, it resembles a saucer turned bottom side up. (Figs. 26, 33, 50.)

Q. What forms the floor of the chest? What organs does the diaphragm separate? What is its form?

90. The chest is enlarged by the movement of the ribs outward and upward and by the movements of the diaphragm downward. Hence the clothing about the lower part of the chest should be worn loosely. (Figs. 26, 27.)

Q. How is the chest enlarged? How should the clothing about the chest be worn?

91. To have good formed chests, the yielding ribs of the child should not be confined by close bands or any kind of tight clothing.

Q. Why should not the child wear close bands or tight clothing?

REVIEW.

85, 86, 87, 88, 89.	<i>Anatomy</i>	} of the THORAX.
85, 89, 90.	<i>Physiology</i>	
90, 91.	<i>Hygiene</i>	

Review by Questions. — What can you tell of the parts that form the thorax? What can you say of the ribs? the diaphragm? What can you relate of the movements of these parts? of the clothing?

REVIEW BY TOPICS. — Give the Anatomy of the thorax, the Physiology, the Hygiene. (See outline anatomical, Plates I. and V.)

LESSON VIII.

92. The blacksmith makes use of bellows to light and increase the heat of the coals in his furnace. So, in the human system, there are organs that act like bellows to kindle the spark of life and produce warmth. These organs are called *Lungs*.

Q. To what may the lungs be compared? How do the lungs resemble a pair of bellows?

THE LUNGS.*

93. The LUNGS are placed in the chest, and enclosed

* Illustrate this lesson by using the trachea and lungs of a pig, sheep, calf, or beef, with outline plates and the blackboard.

by a thin membrane called *pleu'ra*. This membrane also lines the chest. (Fig. 24.)

Q. Where are the lungs situated? What encloses the lungs and also lines the chest?

Remark.—In pleurisy, this membrane is the part diseased.

Q. What part of the chest is diseased in pleurisy?

94. The lungs are yielding, porous organs, and will float on water. For this reason they are often called *lights*. Their color is a pinkish gray. (Fig. 24.)

Q. What is the structure of the lungs? What is their color?

Fig. 24.

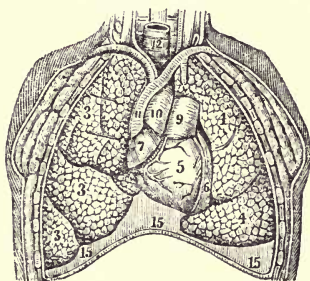


Fig. 25.

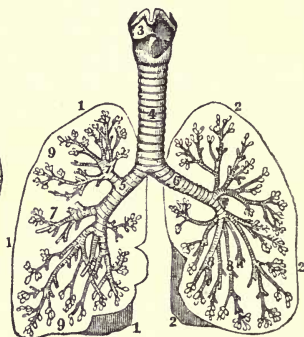


Fig. 24. 3, 3, 3. The lobes of the right lung. 4, 4. The lobes of the left lung. 5, 6, 7. The heart. 9, 10, 11. The large blood vessels. 12. The trachea. 15, 15, 15. The diaphragm.

Fig. 25. 1. Outline of right lung. 2. Outline of left lung. 3, 4. Larynx and trachea. 5, 6, 7, 8. Bronchial tubes. 9, 9. Air cells.

95. Each lung is divided into smaller portions called *lobes*. The left lung has two, and the right lung has three, lobes. (Fig. 24.)

Q. How are the lungs divided?

96. A large tube extends from the mouth to the lungs. It is called *Tra'che-a*, (windpipe.) (Fig. 25.)

Q. What is the trachea?

Fig. 26.

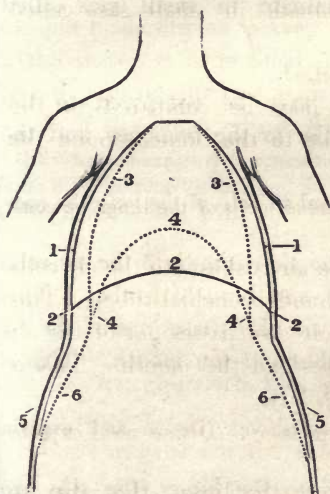


Fig. 27.

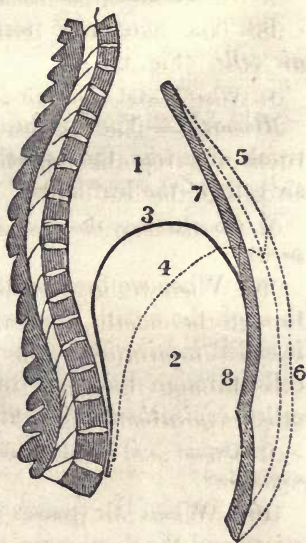


Fig. 26. A front view of the chest and abdomen in respiration. 1, 1. The position of the walls of the chest in inspiration. 2, 2, 2. The position of the diaphragm in inspiration. 3, 3. The position of the walls of the chest in expiration. 4, 4, 4. The position of the diaphragm in expiration. 5, 5. The position of the walls of the abdomen in inspiration. 6, 6. The position of the abdominal walls in expiration.

Fig. 27. A side view of the chest and abdomen in respiration. 1. The cavity of the chest. 2. The cavity of the abdomen. 3. The line of direction for the diaphragm when relaxed in expiration. 4. The line of direction for the diaphragm when contracted in inspiration. 5, 6. The position of the front walls of the chest and abdomen in inspiration. 7, 8. The position of the front walls of the abdomen and chest in expiration.

97. The TRACHEA divides and subdivides in the lungs until the tubes are no larger than small hairs. These divisions are called *Bronch'i-æ*, or bronchial tubes. (Fig. 25.)

Q. What is said of the trachea? Bronchiæ?

98. The BRONCHIÆ terminate in small sacs called *air cells*. (Fig. 25.)

Q. What is said of the air cells?

Remark.—The trachea may be compared to the trunk of a tree, the bronchiæ to the branches, and the air cells to the leaf buds.

Q. To what may the tubes and air cells of the lungs be compared?

99. When we breathe, the air rushes into the air cells through the mouth, trachea, and bronchial tubes. This is called *inspiration*. The air also passes out of the air cells through the same tubes and the mouth. This is called *expiration*. (Figs. 26, 27.)

Q. Define and explain inspiration? Define and explain expiration?

100. When air passes into the lungs, the ribs are raised and the diaphragm sinks; consequently the chest becomes larger. When the air passes from the lungs, the diaphragm is raised and the ribs are depressed; this lessens the size of the chest. These two movements united are called *respiration*, or breathing. (Figs. 26, 27.)

Q. Define and explain respiration?

REVIEW.

93, 94, 95, 96, 97, 98.	<i>Anatomy</i>	} of the LUNGS.
92, 99, 100.	<i>Physiology</i>	
	<i>Hygiene</i>	

Review by Questions.—What will you state of the position and structure of the lungs? What will you say of the trachea? of the bronchiæ? of the air cells? What will you tell of the movement and use of these parts?

REVIEW BY TOPICS.—Give the Anatomy of the lungs, the Physiology, the Hygiene. (See outline anatomical, Plate V.)

LESSON IX.

101. To preserve the life of man and other animals, a fluid called *blood* flows through their bodies. As good blood only gives health and vigor, we find that the Creator has made organs to keep pure this lifegiving fluid. In the insect, it is purified in the skin; in the fish, in the gills; in the inferior animals and man, in the blood vessels of the lungs. (Figs. 34, A, B, p. 48.)

Q. What is necessary to preserve the life of man and animals? Name how the blood is purified in the insect, in the fish, in the inferior animals, and man.

PULMONIC CIRCULATION.*

102. Through the body generally there are three sets of tubes, or blood vessels, called *ar-te-ries*, *veins*, and *cap'il-la-ries*. (Figs. 28, 29, 31, 39, 40, 41.)

Q. What are the blood vessels of the body called?

103. ARTERIES are the tubes that convey the blood *from* the heart to all parts of the body. (Figs. 28, 39.)

Q. Describe arteries?

104. VEINS are the tubes that convey the blood *to* the heart from all parts of the body. (Figs. 29, 40.)

Q. Describe veins.

105. The PULMONARY ARTERY proceeds from the right side of the heart. It divides into two branches, which are spread through the right and left lung. Through this artery and its branches, the blood from the heart flows to the lungs. (Fig. 28.)

Q. Describe the pulmonary artery. What is its use?

* Illustrate this lesson by using the heart of domestic animals, outline plates, and the blackboard.

106. The PULMONARY VEINS commence in the capillaries of the lungs. They unite and reunite until one vein is formed in each lung, these open into the left side of the heart. (Fig. 29.) Through these veins the blood from the lungs flows to the heart.

Q. Describe the pulmonary veins. What are their use?

107. CAPILLARIES are hairlike vessels, placed between the arteries and veins. In the lungs, they form a network over the air cells. In these tubes the blood is purified. (Figs. 30, 31.)

Q. What are the capillaries? What do they form in the lungs? Where is the blood purified?

Fig. 28.

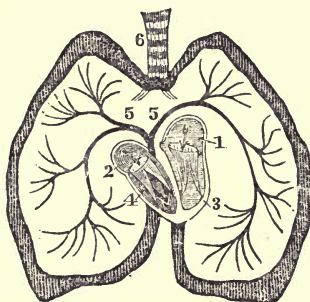


Fig. 29.

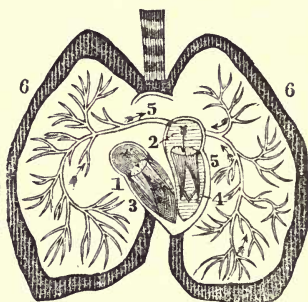


Fig. 28. 1. Left auricle. 2. Right auricle. 3. Left ventricle. 4. Right ventricle. 5, 5. Pulmonary artery. 6. Trachea.

Fig. 29. 1. Right auricle. 2. Left auricle. 3. Right ventricle. 4. Left ventricle. 5, 5. Right and left pulmonary veins. 6, 6. Right and left lung.

REVIEW.

102, 103, 104, 105, 106, 107. *Anatomy*
 101, 103, 104, 105, 106, 107. *Physiology*
Hygiene } of the PULMONIC CIRCULATION.

Review by Questions. — What can you say of arteries, veins, and capillaries? What can you tell of the pulmonic artery? of the pulmonic vein? of the pulmonic capillaries?

REVIEW BY TOPICS. — State the Anatomy of the pulmonic circulation, the Physiology, the Hygiene. (See outline anatomical, Plate VII.)

LESSON X.

108. For man to live, it is necessary that the blood which is carried to the lungs be changed. For this purpose, we find the before-described, simple, and beautiful arrangement. This change is directly effected by a fluid called *air*.

AIR.*

109. Pure AIR, or the invisible substance that we breathe, contains one part of *ox'y-gen* to nearly four parts of *ni'tro-gen*. This is suited to our wants. It was provided by our Creator when he breathed into us the "breath of life."

Q. Of what is pure air composed?

Fig. 30.

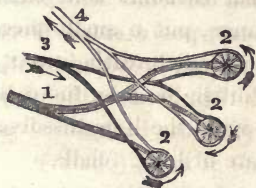


Fig. 31



Fig. 30. 1. A bronchial tube, divided into three branches. 2, 2, 2. Air cells. 3. Branches of the pulmonary artery that spread over the air cells. Through the pulmonary artery, the dark, impure blood is carried to the air cells of the lungs. 4. Branches of the pulmonary vein, that commence at the minute terminations of the pulmonary artery. Through the pulmonary vein the red blood is returned to the heart.

Fig. 31. Capillary blood vessels represented, magnified, as they are spread over the air cells.

* Illustrate this lesson by outline diagrams and by performing the experiments.

110. The impure blood, while in the capillary vessels of the lungs, receives oxygen from the air in the air cells ; and the air in the air cells receives carbonic acid from the blood in the capillary vessels. (Figs. 30, 31.)

Q. How does the blood receive oxygen from the air ? What is received in the air cells of the lungs ?

Observation. — In hemorrhage, or bleeding of the lungs, it is rarely that a blood vessel is broken ; but the blood oozes through the thin walls of the capillary vessels into the air cells — passes into the bronchial tubes, trachea, and mouth.

Q. What is said of bleeding of the lungs ?

111. When the blood parts with carbonic acid gas and receives oxygen, its color is changed from a bluish hue to a scarlet red, and its properties are also altered. (Fig. 30.)

Q. What changes the color and properties of the blood ?

Experiment. — To show that carbonic acid exists in the air expelled from the lungs, put a small piece of lime into a cup of water ; let a pupil breathe into it, and soon the water will become whitish, because the carbonic acid in the breath has united with the lime dissolved in the water and formed carbonate of lime, (chalk.)

Q. How can it be shown that carbonic acid exists in the expired air ?

112. AIR, that has lost a portion of its oxygen and contains carbonic acid, injures the health, because it does not purify the blood in the lungs, by removing the worn-out atoms of the body, in the capillary blood vessels.

Q. Explain how impure air injures the health.

Remark. — Pure air is as necessary to domestic animals as to man. Sheep confined in impure air become diseased of what is called “the rot.”

Q. What is said of pure air for domestic animals?

Experiment. — Breathe into a glass jar until the pure air is displaced by the air from the lungs; then sink a lighted candle into the vessel, and it will be extinguished.

Q. How can you show the presence of carbonic acid in the breath?

Observation. — It is not safe to enter a well, or vault, where a lighted candle will not burn.

Q. What observation in this connection?

113. All rooms should be ventilated, particularly school houses and sleeping rooms. Those persons that breathe the purest air are the most free from coughs, colds, scrofula, and consumption.

Q. Why should rooms be ventilated? What persons are most free from coughs, &c.?

114. When persons are apparently drowned, they can be recovered by forcing air into the lungs and pressing it out again, thus imitating natural breathing.

Q. How should persons apparently drowned be treated?

Remark. — Let the teacher instruct every pupil how to recover asphyxiated persons. (See CUTTER'S Anatomy, Physiology, and Hygiene, page 249.)

REVIEW.

	<i>Anatomy</i>	} of the AIR.
108, 109, 110, 111.	<i>Physiology</i>	
108, 112, 113, 114.	<i>Hygiene</i>	

Review by Questions. — What can you say of the air? How is the blood changed, and where? What can you tell of oxygen? What is the effect of carbonic acid? How can you show this? What can you state of the effects of impure air? What can you tell of ventilation? How should persons apparently drowned be treated?

REVIEW BY TOPICS. — Give the Physiology of Lesson X., the Hygiene.

Fig. 32.

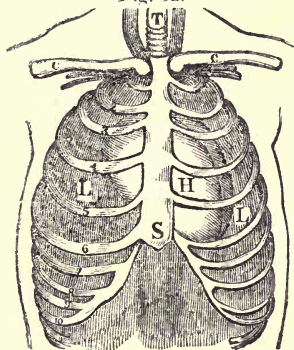


Fig. 33.

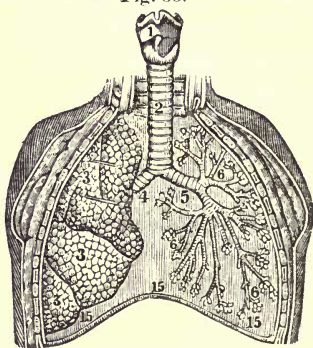


Fig. 34.

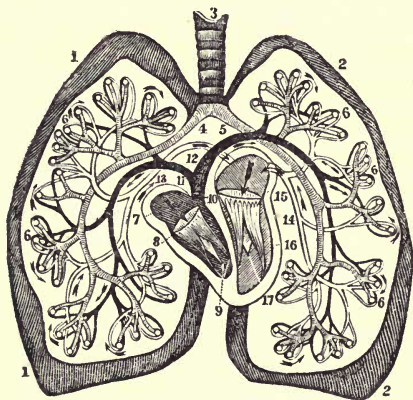


Fig. A.

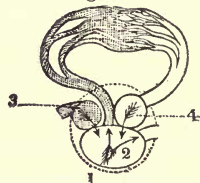


Fig. B.

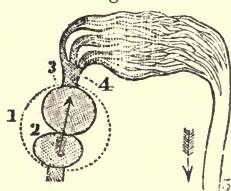


Fig. 32 represents the thorax, enclosing the lungs and heart. S. The sternum. C, C. The two clavicles. T. The trachea. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. The ribs. H. The heart. L, L. The right and left lung.

Fig. 33. 1. The larynx. 2. The trachea. 3, 3, 3. The right lung. 4. The right bronchia. 5. The left bronchia. 6, 6, 6. The air cells. 15, 15, 15. The diaphragm.

Fig. 34. An ideal view of the pulmonic circulation. 1, 1. The right lung. 2, 2. The left lung. 3. The trachea. 4. The right bronchial tube. 5. The left bronchial tube. 6, 6, 6, 6 Air cells. 7. The right auricle. 8. The right ventricle. 9. The tricuspid valves. 10. The pulmonic artery. 11. The branch to the right lung. 12. The branch to the left lung. 13. The right pulmonic vein. 14. The left pulmonic vein. 15. The left auricle. 16. The left ventricle. 17. The mitral valves.

Fig. A. An ideal plan of the pulmonic circulation of a frog. 1. The pericardium. 2 The single ventricle, from which blood passes to both the lungs and body. 3. The right auricle that receives blood from the body. 4. The left auricle that receives blood from the lungs. The arrows indicate the direction of the blood.

Fig. B. An ideal plan of the pulmonic (gill) circulation of a fish. 1. The pericardium. 2. The single auricle. 3. The single ventricle. 4. The vessel that conveys the blood from the ventricle to the gills. 5. The vessel that conveys the blood from the gills to the body of the fish.

SYNTHETIC REVIEW OF THE RESPIRATORY SYSTEM.

86, 87, 88, 89, 85.	Thorax,	}	ANATOMY	} of the RE- SPIRATO- RY SYS- TEM. (Figs. 32, 33, 34.)
93, 94, 95, 96, 97, 98.	Lungs,			
102, 103, 104, 105, 106, 107.	Pulmonic circulation, Air,			
89, 90, 85.	Thorax,	}	PHYSIOLOGY	
99, 100, 92.	Lungs,			
103, 104, 105, 106, 107, 101.	Pulmonic circulation, 109, 110, 111, 108.			
90, 91.	Thorax, Lungs, Pulmonic circulation,	}	HYGIENE.	
112, 113, 114, 108.	Air,			

Review by Questions. — What can you say of the parts of the thorax? What can you tell of the structure of the ribs? of the diaphragm? What can you state of the anatomy of the lungs? of the trachea? of the bronchiæ? of the air cells? What can be said of the structure and distribution of the pulmonic artery? of the pulmonic vein? of the pulmonic capillary vessels?

What can you tell of the use of each of the above-named parts? What can you say of the air?

How is health preserved? How may apparently drowned persons be recovered?

REVIEW BY TOPICS. — Give the Anatomy of the respiratory system, the Physiology, the Hygiene. (Use outline anatomical, Plates I., V., VII.)

CHAPTER III.

THE CIRCULATORY SYSTEM embraces the heart, the arteries, and veins of the lungs, together with the arteries and veins of the general system. (Fig. C, p. 64.)

Q. What does the circulatory system embrace?

LESSON XI.

115. In many cities pipes are laid under the streets, through which water runs to every house from a large cistern, or reservoir. When the water has supplied the wants of the people, another set of pipes carries it away. So in the body there are two sets of tubes (veins and arteries) that carry blood to and from the organ called the *heart*. (Figs. 28, 29, 39, 40.)

Q. How is the human body supplied with blood?

THE HEART.*

116. The HEART inclines to the left side of the chest, and is placed between the lungs. The point of the heart is directed downward, and rests on the diaphragm. (Fig. 50.)

Q. Where is the heart placed? Upon what does it rest?

117. The heart is enclosed in a firm membrane called *per-i-car'di-um*, (heart case.) (Fig. 35.)

Q. What encloses the heart?

118. The substance of the heart is a mass of flesh,

* Illustrate this lesson by using the hearts of animals, birds, and fishes with outline diagrams and the blackboard. (See *Preface*.)

so arranged as to form two sides and four cavities. (Fig. 36.)

Q. Of what is the heart composed? How is it arranged?

119. The two upper cavities are called *au'ri-cles*, (deaf ears.) The two lower cavities are called *ven'tri-cles*. Thus we have a right and left auricle, and a right and left ventricle. (Fig. 36.)

Q. What are the cavities of the heart called? Describe them.

Fig. 35.

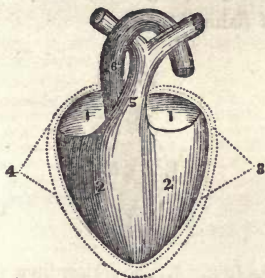


Fig. 36.

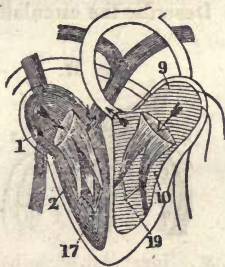


Fig. 35. 1, 1. Right and left auricle. 2, 2. Right and left ventricle. 3, 4. The pericardium. 5, 6. Large blood vessels, (arteries.)

Fig. 36. Ideal heart. 1. Right auricle. 2. Right ventricle. 9. Left auricle. 10. Left ventricle. 17. Tri-cuspid valves. 19. Mitral valves.

120. The **AURICLES** receive blood from the body and from the lungs. The **VENTRICLES** send blood to the body and lungs. (Figs. 28, 29, 39, 40.)

Q. What is the use of the auricles? Of the ventricles?

121. In the **MAMMALIA**, as the horse, ox, &c., the heart has four cavities, two auricles, two ventricles, and valves, as in man. (Fig. 36.)

Q. Describe the heart of the mammalia, as the horse.

122. In the AMPHIBIA and perfect reptiles, as the frog and snake, the heart has three cavities, two auricles, and one ventricle. One auricle receives blood from the system, the other from the lungs. The ventricle sends blood both to the system and the lungs. (Figs. 37, 44.)

Q. Describe the circulation of frogs and snakes.

123. FISHES have a distinct heart, with but one auricle and one ventricle. The auricle receives blood from the body. The ventricle sends it to the gills. From the gills it is carried to the body. (Figs. 38, 45.)

Q. Describe the circulation of fishes ?

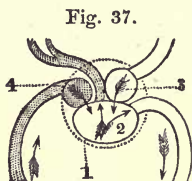


Fig. 37.

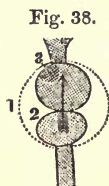


Fig. 38.

Fig. 37. Ideal plan of the heart of a frog. 1. The pericardium, (heart case.) 2. The single ventricle. 3. The auricle that receives blood from the lungs. 4. The auricle that receives blood from the body. The arrows show the direction of the blood.

Fig. 38. Ideal plan of the heart of the fish. 1. The pericardium. 2. The ventricle that receives blood from the body. 3. The ventricle that sends blood to the gills.

124. INSECTS have no heart ; but they have a central pulsating vessel.

Q. Describe the circulation of insects.

125. The size of the heart varies in different persons. It weighs about eight and a half ounces. Each cavity in an adult holds about half a gill of blood.

Q. What is the size of the heart ?

126. Between the cavities of each side of the heart there are thin membranes called *valves*. Those in the right side are called *tri-cuspid* valves; those in the left side, *mi'tral* valves. These valves allow the blood to pass only in one direction—from the auricles into the ventricles. (Fig. 36.)

Q. What is placed between the cavities of the heart? What is the name of those in the right side of the heart? In the left side? What is the use of these valves?

REVIEW.

115, 116, 117, 118, 119, 121, 122, 123, 124, 125. . . *Anatomy*
119, 120, 122, 123, 126. *Physiology* } of the HEART.
Hygiene

Review by Questions.—What can you say of the position and substance of the human heart? What of the auricles? of the ventricles? of the valves? What can you state of the heart of animals? of reptiles? of fishes? of insects? What can you tell of the use of the auricle? of the ventricle? of the valves? What can you state of the use of the different parts of the heart in animals? in reptiles? in fishes?

REVIEW BY TOPICS.—Give the Anatomy of the heart, human and comparative, the Physiology, the Hygiene. (See outline anatomical, Plate VI.)

LESSON XII.

127. In those cities that receive their supply of water from a reservoir, care is taken that every family may have its needful quantity. Thus in the human body, every organ receives its due supply of blood; and the distribution of the lifegiving fluid is called the *systemic circulation*. (Figs. 39, 40, 41, 42.)

Q. What is the distribution of blood throughout the body called?

SYSTEMIC CIRCULATION.*

128. The SYSTEMIC CIRCULATION consists of the *a-orta* and branches, *ve'na ca'va* and branches, *capillaries*,

* Illustrate this lesson by using the heart and blood vessels of domestic animals, outline diagrams, and blackboard.

ve'na por'ta, lac'te-als, and ab-sorb'ents. (Figs. 39, 40 41, 42.)

Q. Name the vessels which comprise the systemic circulation

Fig. 39.

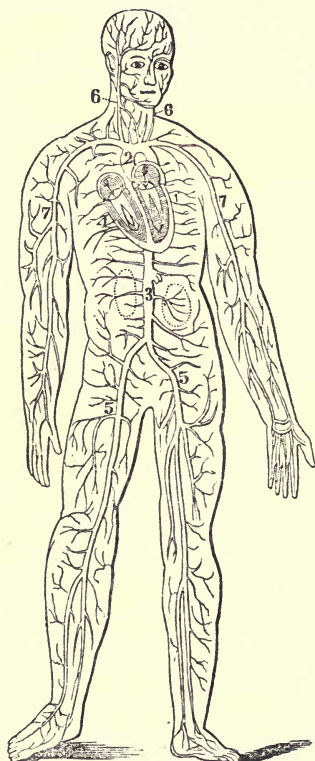


Fig. 40.

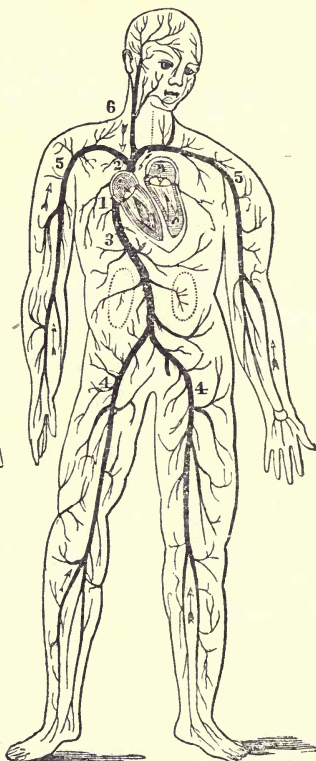


Fig. 39. 1. Left ventricle of the heart. 2, 3. Aorta. 5, 5. Arteries that extend to the lower extremities. 6, 6. Arteries of the neck. 7, 7. Arteries of the arms.

Fig. 40. 1. Right auricle of the heart. 2, 3. Large veins that open into the right auricle. 4, 4. Veins of the lower extremities. 5, 5. Veins of the arms. 6. Veins of the neck. The arrows show the direction that the blood flows.

129. The AORTA, or large artery, arises from the left ventricle of the heart, and its branches extend to every part of the body. Through these vessels the purified blood flows to the systemic capillaries. (Fig. 39.)

Q. Through what vessels does the blood flow to every part of the body?

130. At the commencement of the aorta are three valves, called *sem-i-lu'nar*. These prevent the blood returning to the heart. (Fig. 39.)

Q. Where are the semilunar valves, and what is their use?

131. The SYSTEMIC VEINS commence in the capillaries of the body. They unite and reunite until two large veins are formed, (called *vena cava*, ascending and descending.) These open into the right auricle of the heart. The blood from all parts of the body flows to the heart through these veins. (Fig. 40.)

Q. Describe the systemic veins. What is their use?

132. The CAPILLARY VESSELS of the body resemble in structure the capillaries of the lungs. They also connect the minute arteries and veins. They receive red blood from the arteries and impart dark blood to the veins. (Fig. 41.)

Q. Describe the capillary vessels. What do they connect? What do they receive? What do they impart to the veins?

133. The VENA PORTA is formed of veins from the stomach, spleen, pancreas, small and large intestine. By this vein the blood is conveyed into and distributed through the liver. This is called the *portal circulation*.

Q. Of what is the vena porta composed? What is the use of this vessel? What is this circulation called?

134. The LACTEAL VESSELS commence in the small intestine. They open into the thoracic duct. This

opens into a systemic vein. The chyle, or the nourishing part of the food, is conveyed into the veins by these vessels. (Fig. 42.)

Q. Where do the lacteal vessels commence, and into what do they open? Into what does the thoracic duct open? Where is the chyle conveyed?

Fig. 41.

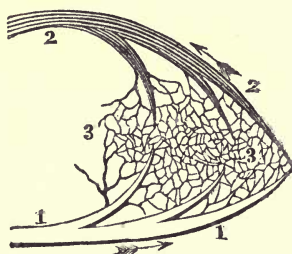


Fig. 41. Ideal plan of capillary vessels. 1. An artery. 2. A vein. 3, 3. Capillary vessels. The arrows show the direction of the blood.

135. The ABSORBENTS are minute vessels that open into the thoracic duct and into veins directly. They are found in every part of the body except the brain. They convey lymph and waste matter into the systemic veins. (Fig. 42.)

Q. What is said of the absorbents? What is their use?

136. The blood that is carried by the veins into the right auricle of the heart is composed of materials received from the capillaries, the lacteals, and the absorbents. (Figs. 40, 41, 42.)

Q. Of what is the blood in the veins composed?

Fig. 42.

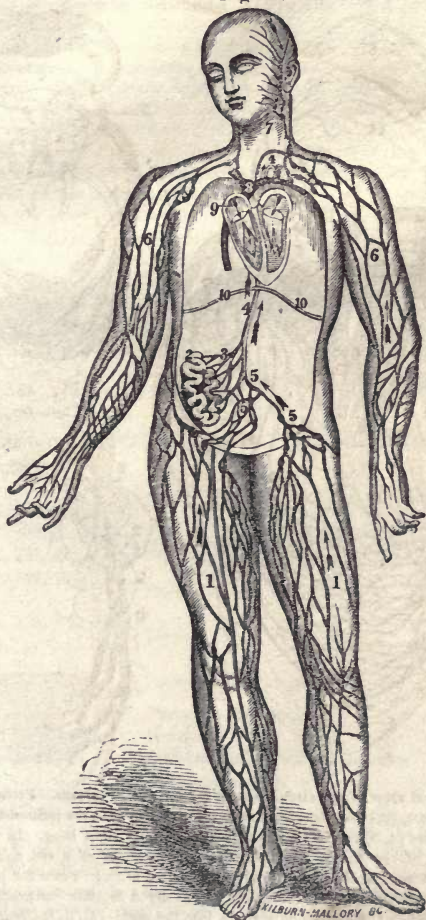


Fig. 42. 1, 1. The absorbents of the lower extremities. 2. The small intestine 3. The lacteals. 4, 4. The thoracic duct. 5, 5. Absorbent ducts. 6, 6. Absorbents of the arms. 7. Absorbents of the neck. 8. A large vein that opens into the right auricle of the heart. 9. The right auricle. 10, 10. The diaphragm. (See p. 60.)

Fig. 43.

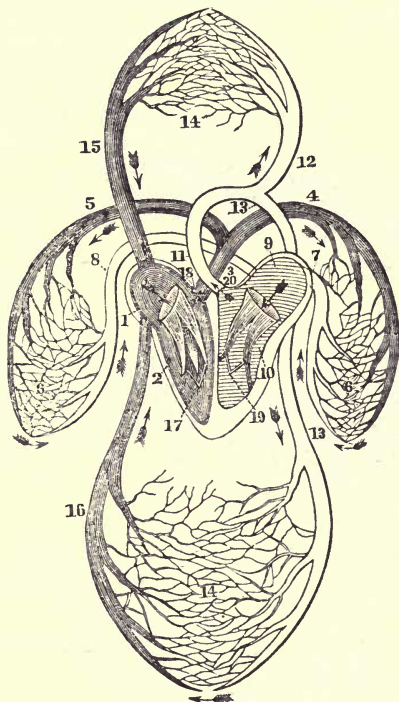


Fig. 44.

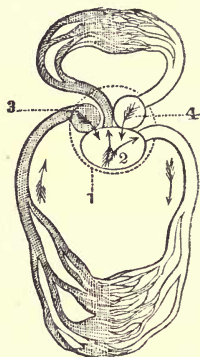


Fig. 45.

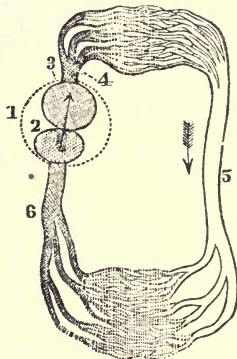


Fig. 43. An ideal view of the circulation in the lungs and system. From the right ventricle of the heart, (2,) the dark, impure blood is forced into the pulmonary artery, (3,) and its branches (4, 5) carry the blood to the left and right lung. In the capillary vessels (6, 6) of the lungs the blood becomes pure, or of a red color, and is returned to the left auricle of the heart (9) by the veins, (7, 8.) From the left auricle the pure blood passes into the left ventricle, (10.) By a forcible contraction of the left ventricle of the heart, the blood is thrown into the aorta, (11.) Its branches (12, 13, 13) carry the pure blood to every organ or part of the body. The divisions and subdivisions of the aorta terminate in capillary vessels, represented by 14, 14. In these hairlike vessels the blood becomes dark colored, and is returned to the right auricle of the heart (1) by the vena cava descendens, (15,) and vena cava ascendens (16.) The tricuspid valves (17) prevent the reflow of the blood from the right ventricle to the right auricle. The semilunar valves (18) prevent the blood flowing from

the pulmonary artery to the right ventricle. The mitral valves (19) prevent the reflow of blood from the left ventricle to the left auricle. The semilunar valves (20) prevent the reflow of blood from the aorta to the left ventricle. The left ventricle, aorta and branches, vena cava and branches, capillaries, lacteals, and absorbents, with the right auricle, compose the systemic circulation. (Figs 36, 39, 40, 41, 42, 43.) The right ventricle, pulmonary artery and branches, capillaries, pulmonary veins, and left auricle, compose the pulmonic circulation. (Figs. 28, 29, 30, 43.)

Fig. 44 An ideal plan of the circulation of a frog. 1. The pericardium. 2. The single ventricle, from which blood passes to both the lungs and body. 3. The right auricle that receives blood from the body. 4. The left auricle that receives blood from the lungs. The arrows indicate the direction of the blood.

Fig. 45. An ideal plan of the circulation of a fish. 1. The pericardium. 2. The single auricle. 3. The single ventricle. 4. The vessel that conveys the blood from the ventricle to the gills. 5. The vessel that conveys the blood from the gills to the body of the fish. 6. The vessel that conveys the blood from the body to the heart. The arrows show the direction of the blood.

SYNTHETIC REVIEW OF THE CIRCULATORY SYSTEM

115, 116, 117, 118, 119. }			
121, 122, 123, 124, 125. }	Heart,		
127, 128, 129, 130, 131, }			
132, 133, 134, 135. . . }	Systemic circulation,	ANATOMY	
102, 103, 104, 105, 106, }			
107. }	Pulmonic circulation,		
119, 120, 121, 122, 123, }			
124, 126. }	Heart,		
127, 129, 130, 131, 132, }			
133, 134, 135, 136, 137, 138. }	Systemic circulation,	PHYSIOLOGY	
103, 104, 105, 106, 107. }	Pulmonic circulation,		
	Heart,		
139. }	Systemic circulation,		
	Pulmonic circulation,	HYGIENE	
			of the CIRCULATORY SYSTEM. (Figs. 43, 44, 45.)

Review by Questions.—What are the parts of the heart in man? in animals? in perfect reptiles? in fishes? What can you tell of the auricle? of the ventricle? of the valves? What are the parts of the systemic circulation? What can you say of the structure of the aorta and branches? of the vena cava and branches? of the systemic capillaries? of the vena porta? of the lacteals and thoracic duct? of the absorbents? What are the parts of the pulmonic circulation? What can you say of the pulmonic artery? of the pulmonic veins? of the pulmonic capillaries? What parts of the heart are connected with the pulmonic circulation? with the systemic circulation?

What can you say of the use of the before-mentioned parts? Where and in what vessels is the blood purified? Where and by what vessels is the system built up? How is it pulled down?

What can you say of the preservation of health? of the prevention of disease? of the treatment of asphyxia? of bleeding from divided arteries?

REVIEW BY TOPICS.—Give the Anatomy of the circulatory system, the Physiology the Hygiene. (Use outline anatomical, Plates V., VI., VII.)

137. The different parts of the body, as fat, skin, muscle, brain, bone, &c., are made from the *blood* by the action of the *systemic capillary vessels*.

Q. What is the use of the systemic capillary vessels?

138. The waste, wornout atoms are removed from the body by the skin, lungs, liver, kidneys, pancreas, and salivary glands. These are the "pullers down" of the system.

Q. How are the waste atoms removed?

139. If a large artery is cut and the blood flows fast, pressure should be made by the finger or a compress on the wounded artery until a physician can be called.*

Q. How should bleeding be treated?

(For PULMONARY CIRCULATION, see Lesson IX.)

REVIEW.

127, 128, 129, 130, 131, 132, 133, 134, 135.	<i>Anatomy</i>	} of the Sys- TEMIC CIR- CULATION.
127, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138.	<i>Physiology</i>	
139.	<i>Hygiene</i>	

Review by Questions. — What are the parts of the systemic circulation? What is the anatomy of the aorta and branches? of the vena cava and branches? of the systemic capillaries? of the vena porta? of the lacteals? of the absorbents? What is the use of the aorta and branches? of the vena cava and branches? of the vena porta? of the lacteals? of the absorbents? What can you tell of the building up of the system? of the pulling down of the body? How should bleeding from a divided artery be treated?

REVIEW BY TOPICS. — Give the Anatomy of the systemic circulation, the Physiology, the Hygiene. (See outline anatomical, Plate VI.)

REVIEW LESSON. — (See p. 58.)

* Let pupils be instructed in the treatment of wounds and stoppage of blood. (See CUTTER'S Anatomy, Physiology, and Hygiene, page 175.)

LESSON XIII.

140. Many kinds of musical instruments have been made ; but none compare in simplicity of structure to the organs of speech. No instrument can produce sounds so varied and sweet as the human voice. These ever-varying notes are the result of the training of small muscles, over which the reader, orator, and singer should have a quick as well as perfect control. A knowledge of the Anatomy, Physiology, and Hygiene of the *vocal organs* is necessary to correct instruction in reading and singing.

VOCAL ORGANS.*

141. The VOCAL ORGANS may be divided into the *larynx*, the *mouth*, and the *respiratory organs*. (Figs. 12, 50.)

Q. How may the vocal organs be divided ?

142. The LARYNX consists of five pieces of cartilage, (gristle,) forming a kind of box, open at each end. It is situated at the upper part of the trachea, (windpipe,) below the chin. (Figs. 46, 47.)

Q. Describe the larynx. Where is it situated ?

Remark. — It is this part of the “windpipe,” so prominent in man, that is called the “apple of Adam.”

143. There are stretched across the larynx four bands, (called ligaments, or cords,) two on each side of the tube. These vocal ligaments are so arranged as to form an

* Illustrate this lesson by using the corresponding organs of domestic animals, with outline diagrams and the blackboard.

opening, (*ri'ma glot-ti'dis*,) through which the air may pass. (Fig. 47.)

Q. Describe the vocal ligaments? What is said of the rima glottidis?

Fig. 46.

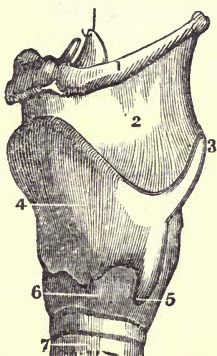


Fig. 47.

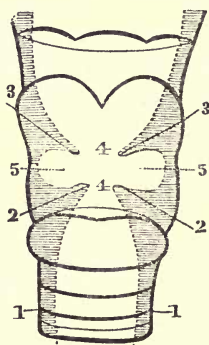


Fig. 46. A side view of the larynx. 1. Bone at base of tongue, (os hyoides.) 3, 4, 5, 6. Larynx. 7. Trachea.

Fig. 47. An ideal section of the larynx. 1. The trachea. 2, 2. The lower vocal cords. 3, 3. The upper vocal cords. 4, 4. Rima glottidis. 5, 5. Cavities between upper and lower vocal cords.

144. The air, in passing from the lungs, causes the vocal ligaments to vibrate, and produces the first, or basement tone, as touching the strings of a harp or violin causes a vibratory motion, attended with sound. (Fig. 47.)

Q. How is the basement tone produced? What illustration is given?

145. The MOUTH contains the tongue, teeth, lips, and palate. These parts, with the passages of the nose, vary or articulate the basement tone. (Fig. 12.)

Q. What parts of the mouth are used in articulation?

146. The ORGANS OF RESPIRATION (breathing) supply the current of air that produces the movements of the vocal ligaments.

Q. What is the use of the organs of respiration in speaking?

Fig. 48.



Fig. 49.



Fig. 48. An improper position; but one not unfrequently seen in some of our common schools and in some of our public speakers.

Fig. 49. The proper position for reading, speaking, and singing.

147. But few, if any, of the reptiles, as the snake, can produce any other sound than a hiss; while most of the
(See p. 66.)

Fig. 50.

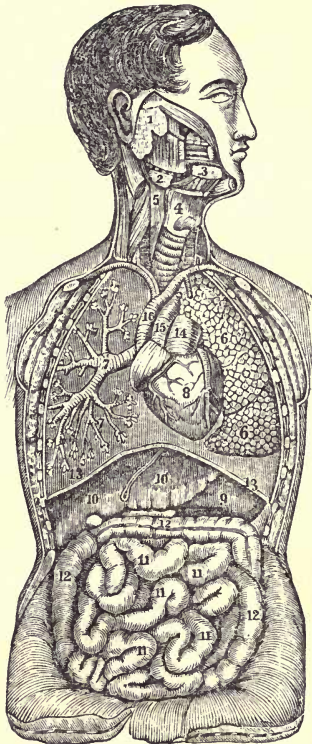
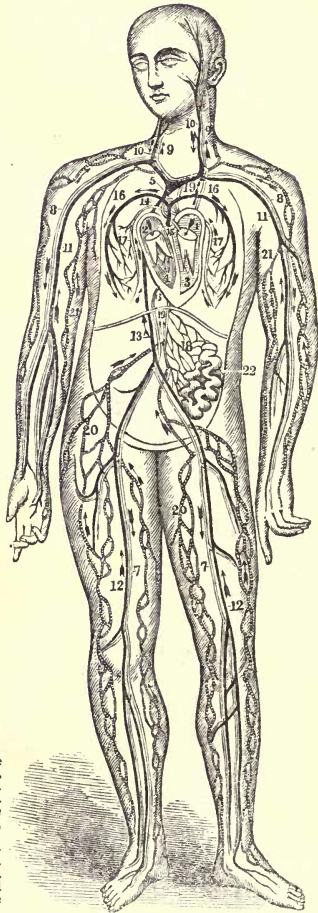


Fig. 50. 1, 2, 3. The salivary glands. 4. The trachea. 5. The œsophagus. 6, 6. The left lung. 7, 7, 7. The bronchia and air cells of right lung. 8. The heart. 9. The stomach. 10, 10. The liver. 11, 11, 11. The small intestine. 12, 12, 12. The large intestine. 13, 13. The diaphragm. 14, 15, 16. Blood vessels connected with the heart.

Fig. C. 1. The left auricle. 2. The right auricle. 3. The left ventricle. 4. The right ventricle. 5, 6. The aorta. 7, 7. The femoral (leg) arteries. 8, 8. The brachial (arm) arteries. 9, 9. The carotid arteries. 10, 10. The jugular veins. 11, 11. The brachial veins. 12. The femoral veins. 13, 14. The vena cava. 15. The pulmonary artery. 16, 16. The right and left pulmonary arteries. 17, 17. The pulmonary veins. 18. The lacteals. 19, 19. The thoracic duct. 20, 20. The absorbents of the lower extremities. 21, 21. The absorbents of the upper extremities. 22. The small intestine.

Review by Questions.—What can you say of the Anatomy of the digestive organs? of the respiratory organs? of the circulatory organs? of the vocal organs? What can you tell of the use of the digestive system? of the respiratory system? of the circulatory system? of the vocal system? What can you state of food? of air? of blood? of building up the system? of pulling down the system? What will you say of means to prevent disease? to preserve health? **How should accidents be treated, as poisoning? drowning? bleeding from divided arteries?**

Fig C.



SYNTHETIC REVIEW OF NUTRITIVE APPARATUS

30, 31, 32, 33, 34, 35, 36, 37, 38, 40.	Teeth,	DIGESTIVE SYSTEM,	ANATOMY	
44, 47.	Salivary glands,			
49, 50, 51, 53, 54. . . .	Stomach,			
62, 63, 64, 65, 66, 67. . .	Small intestine,			
72, 73.	Lacteals,			
78, 79, 80.	Large intestine,	RESPIRATORY SYSTEM,		
86, 87, 88, 89.	Thorax,			
93, 94, 95, 96, 97, 98. . .	Lungs,			
102, 103, 104, 105, 106, } 107.	Pulmonic cir- culation, Air,			
115, 116, 117, 118, 120, } 121, 122, 123, 124. . . .	Heart,			CIRCULATORY SYSTEM,
127, 128, 129, 130, 131, } 132, 133, 134, 135. . . .	Systemic cir- culation, Pulmonic cir- culation,			
102, 103, 104, 105, 106, } 107.	Pulmonic cir- culation,			
141, 142, 143, 145. . . .	Vocal organs,			
29, 34, 37, 38, 39, 40. . .	Teeth,	VOCAL SYST.,		
44, 47.	Salivary glands,	DIGESTIVE SYSTEM,	PHYSIOLOGY	
51, 52, 55, 56, 57. . . .	Stomach,			
64, 65, 66, 67, 68. . . .	Small intestine,			
74, 75.	Lacteals,			
81.	Large intestine,			
89, 90.	Thorax,	RESPIRATORY SYSTEM,		
99, 100.	Lungs,			
103, 104, 105, 106, 107. } 109, 110, 111.	Pulmonic cir- culation, Air,			
119, 120, 121, 122, 123, } 124, 126.	Heart,			CIRCULATORY SYSTEM,
127, 129, 130, 131, 132, } 133, 134, 135, 136, 137. .	Systemic cir- culation, Pulmonic cir- culation,			
103, 104, 105, 106, 107. } 143, 144, 145, 146, 147. .	Pulmonic cir- culation, Vocal organs,			
41, 42.	Teeth,	VOCAL SYST.,		
45, 46.	Salivary glands,	DIGESTIVE SYSTEM,		
57, 58, 59 60.	Stomach,			
67, 69, 70.	Small intestine,			
76.	Lacteals,			
81, 82, 83.	Large intestine,			
90, 91.	Thorax,	RESPIRATORY SYSTEM,		
	Lungs,			
	Pulmonic cir- culation,			
112, 113, 114.	Air,		CIRCULATORY SYSTEM,	
139.	Heart,			
	Systemic cir- culation, Pulmonic cir- culation,			
148, 149, 150.	Vocal organs,	VOCAL SYST.,		

OF THE NUTRITIVE APPARATUS. (Figs. 20, 50.)

REVIEW BY TOPICS.—Give the Anatomy of the Nutritive Apparatus, the Physiology, the Hygiene. (Use outline anatomical, Plates I., III., V., VI., VII.)

(65)

mam-ma'li-a, as the ox, horse, dog, and cat, can make vocal sounds.

Q. What is said of reptiles? Of the mammalia?

148. To read, speak, and sing, distinctly and with taste, the head should be held easily erect, so that the movements of the vocal organs may be gentle and effectual. The book, also, should be held at a proper distance from the face. (Figs. 48, 49.)

Q. What should be the position of the head in reading or singing? Why? How should the book be held?

149. Good and elegant reading, speaking, and singing, require that the shoulders be thrown back and the body held easily erect, so that there may be a free movement of the organs of the chest. (Fig. 49.)

Q. What should be the position of the shoulders in reading? Of the body? Why?

150. Singing and reading aloud, in a correct position, strengthen and improve the vocal organs, as well as prevent disease of the throat and lungs.

Q. What is said of the effects of singing and reading?

Remark. — Repetition is necessary in learning to read. It is better that a child read a sentence again and again, until it is understood and read correctly, than to read pages poorly and know nothing of what they have been reading.

REVIEW.

140, 141, 142, 143, 145.	. <i>Anatomy</i>	} of the VOCAL ORGANS.
143, 144, 145, 146, 147.	. <i>Physiology</i>	
148, 149, 150. <i>Hygiene</i>	

Review by Questions. — What parts are employed in speech? What can you say of the structure of the larynx? of the mouth? of the lungs? What can you tell of the use of the larynx? of the mouth and its parts? of the lungs? What will you state of position in reading? in speaking? in singing?

REVIEW BY TOPICS. — Give the Anatomy of the vocal organs, the Physiology, the Hygiene. (See outline anatomical, Plates I., III., and V.) (Review lesson, see p.64.)

PART II.

151. In this part the NERVOUS APPARATUS will be described. It embraces the *Brain* and *Spinal Cord*, (*cer'e-bro-spinal axis*,) and the organs or instruments of *special sensation* — as the eye, ear, &c. (Figs. 59, 60, 61, 62, 65, see p. 90.)

Q. What is the subject of Part II.? What does the nervous apparatus embrace?

CHAPTER I.

152. In this chapter we shall treat of the *brain* and *spinal cord* — organs that exercise an important influence upon every part of the body. (Fig. 59.)

Q. What is the subject of Chapter I. Part II.?

LESSON XIV.

153. In large hotels, it would not be convenient for boarders occupying rooms to ascend and descend several flights of stairs to make known their wants; therefore, from a room called the office, wires or tubes pass to all the apartments of the house, by which messages are sent. So in the human system we find a beautiful dome-shaped office, where a great deal of work is done. This busy workshop is the *brain*, and its errands are carried through-

out the “house we live in” by means of its bell wires—the *spinal cord* and *nerves*. (Fig. 59.)

Q. What is said of the dome-shaped office and bell wires of the body?

BRAIN.*

154. The **BRAIN** is a soft, pulpy mass within the skull bones. It is divided into two portions, called the *cer'e-brum* (large brain) and *cer-e-bel'lum*, (small brain.) (Figs. 51, 52.)

Q. How is the brain divided? What are the parts called?

Fig. 51.

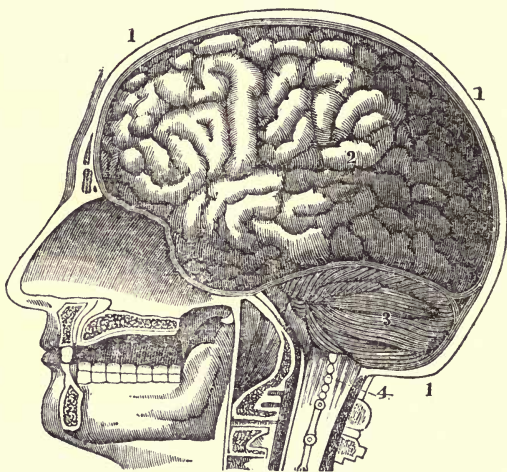


Fig. 5. Side view of the brain. 1, 1, 1. The bones of the skull. 2. The large brain. 3. The small brain. 4. The spinal cord.

* Illustrate this lesson by using the brain of domestic animals, with diagrams and the blackboard. (See *Preface*.)

155. The CEREBRUM is the upper and front portion. The outside is irregular, like a peach stone. These irregularities are called *convolutions*. (Fig. 51.)

Q. Where is the cerebrum situated? What is its appearance? What are the irregularities called?

Fig. 52.

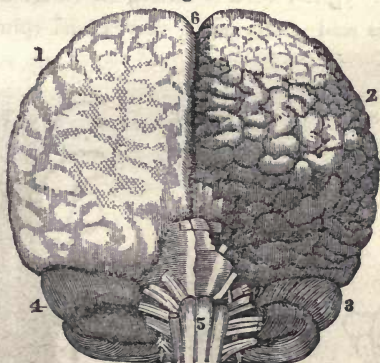


Fig. 52. Back view of the brain. 1. The large brain, covered with its membranes. 2. The brain without the membranes, exhibiting their irregularities. 3, 4. The small brain. 5. The spinal cord. 6. The fissure between the two sides.

156. The CEREBELLUM is placed at the lower and back part of the skull. It is smaller than the cerebrum, and has a smooth surface. (Figs. 51, 52.)

Q. Where is the cerebellum situated? Describe it.

157. The brain, both large and small, is divided into two sides, or hemispheres. The whole is surrounded by membranes as well as bones. (Fig. 52.)

Remark. — The brain is quite soft in childhood, and blows upon the skull bones may produce disease, and

even death. Hence no child should ever be struck upon the head.

Q. Why should not a child be struck upon the head ?

158. In BIRDS, the large and small brain are nearly of the same size ; but the small brain is not divided into two parts. Where the nerves of the legs and wings originate, the spinal cord is enlarged. (Fig. 53.)

Q. What is said of the brain, nerves, and spinal cord of a bird ?

Fig. 53.

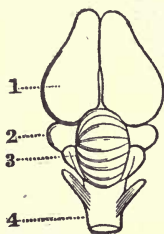


Fig. 54.

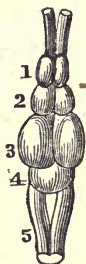


Fig. 55.

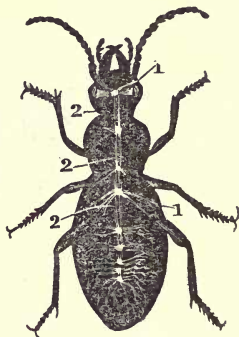


Fig. 53. Brain of a bird. 1. The large brain. 2. The optic ganglia. 3. The small brain. 4. The spinal cord.

Fig. 54. Brain of a fish. 1. The ganglia of smell. 2. The large brain. 3. The ganglia of sight. 4. The small brain. 5. The spinal cord.

Fig. 55. Nervous system of an insect. 1, 1. Central ganglia. 2, 2, 2. Nerves that connect the ganglia.

159. In FISHES, the brain is much smaller than the points from which the nerve of sight proceeds. The spinal cord is large, and divided at its commencement

into two parts. The vision of a fish is very acute. (Fig. 54.)

Q. What is said of the brain and spinal cord of a fish? Of the vision of a fish?

160. In INSECTS there are *gan'gli-a*, or central points, in the head and at each section of the body. These points are united by a double cord. The nerves proceed from these central points. (Fig. 55.)

Q. What is said of the nervous system of insects?

161. The human brain is an instrument or organ of the mind and centre of sensation. Its size, health, and activity generally measure the amount of mental power and acuteness of sensation.

Q. What is the use of the brain? What generally measures the amount of mental power?

162. The brain is largely supplied with blood. The health of the organ and the power of the mind require that the blood that flows to this organ be pure.

Q. With what is the brain supplied? What should be the quality of the blood that flows to the brain? Why?

163. To educate the mind or train the brain, there must be repeated effort, as in learning to use the vocal organs.

Q. What is necessary to educate the mind or train the brain?

164. The brain may be overworked; but, where sleep is *regular* and *refreshing*, there is but little danger of disease.

Q. What is needful to prevent disease of the brain?

165. In illness, the brain is more sensitive than in health. Sick rooms, particularly *those of children*, should not be thronged with visitors.

Q. What is said of the brain when we are ill? Of sick rooms?

REVIEW.

151, 152, 154, 155, 156, 157, 158, 159, 160.	<i>Anatomy</i>	} of the BRAIN.
153, 161, 162.	<i>Physiology</i>	
162, 163, 164, 165.	<i>Hygiene</i>	

Review by Questions. — How is the nervous apparatus divided? How is the brain divided? What can you state of the cerebrum? of the cerebellum? How are both divided? What invests them? What can you say of the nervous system of birds? of fishes? of insects? What can you tell of the use of the brain? of the blood of the brain? of sleep? of sickness?

REVIEW BY TOPICS. — Give the Anatomy of the brain, the Physiology, the Hygiene. (See outline anatomical, Plates I. and VIII.)

LESSON XV.

166. In this lesson we shall treat of the little sentinels that keep such strict watch over the “house we live in.” These body guards warn us instantly of danger, and tell by their sensitiveness when the house is crumbling or needs repairing; and some of them increase our happiness by conveying impressions of the life and light of this beautiful world. These useful instruments, or organs, are the *nerves* that pass from the brain and *spinal cord*. (Figs. 56, 57, 58.)

Q. To what are the nerves compared?

SPINAL CORD AND NERVES.*

167. The SPINAL CORD (pith of the back bone) connects with the brain. It is placed in the canal formed by the bones of the spinal column. (Fig. 57.)

Q. Where is the spinal cord situated?

* Illustrate this lesson by using the bones of the spinal column, the spinal cord and nerves of domestic animals, with outline diagrams and blackboard.

168. The **NERVES** are small white cords, that are spread through every part of the body. They are composed of matter similar to the brain and spinal cord. Like the brain, they are enclosed in a delicate sheath, or membrane. (Figs. 56, 59.)

Q. Describe the nerves.

169. The nerves that pass from the brain are named *crani-al* nerves. (Fig. 56.) Those that proceed from the spinal cord are called *spinal* nerves. (Fig. 59.)

Q. What are the nerves called that pass from the brain?
Of the spinal cord?

Fig. 56.

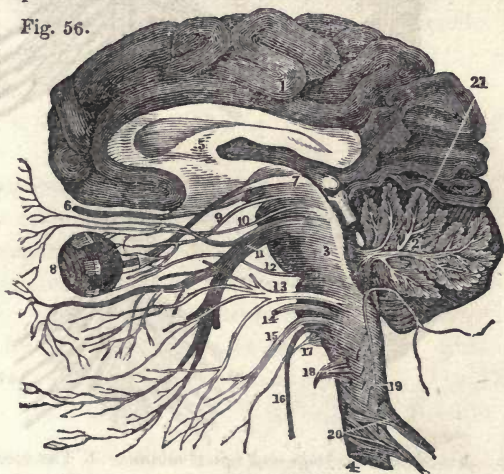


Fig. 56. A vertical section of the large and small brain and spinal cord. 1. The large brain. 2. The small brain. 3, 4. The spinal cord. 6. Nerve of smell. 7, 8. The eye and nerve of sight. 9, 10, 11, 12, 13, 14 15, 16, 17, 18, 19, 20. Nerves of the face and head.

170. The **CRANIAL**, or brain nerves are divided into twelve pairs. These pass to the eye, ear, nose, tongue, teeth, and parts about the face. (Fig. 56.)

Q. How many pairs of cranial nerves? How are they distributed?

Fig. 57.

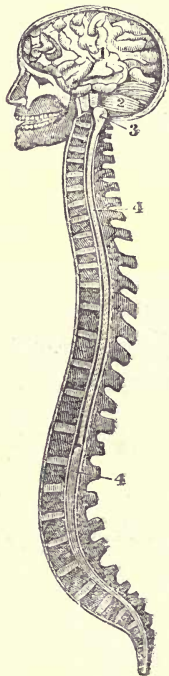


Fig. 58.

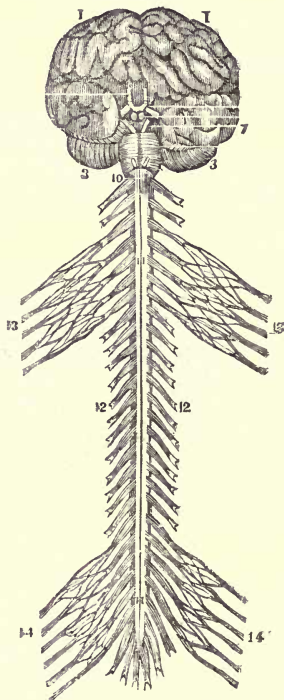


Fig. 57. A section of the brain and spinal column. 1. The cerebrum, (large brain.) 2. The cerebellum, (small brain.) 3, 4, 4. The spinal cord in its canal.

Fig. 58. Anterior view of the brain and spinal cord. 1, 1. The two hemispheres of the cerebrum. 3, 3. The cerebellum. 7, 10, 11, 11. The spinal cord. 12, 12. Spinal nerves. 13, 13. The brachial plexus. 14, 14. The lumbar and sacral plexus.

171. The SPINAL nerves are divided into thirty pairs. These proceed from the spinal cord. Each spinal nerve has two roots. (Figs. 58, 59.)

Q. How many pairs of nerves proceed from the spinal cord? How many roots have the spinal nerves?

172. The spinal nerves are distributed to the muscles of the body, upper and lower extremities, and the skin.

Q. How are the spinal nerves distributed?

173. One root of the nerve gives sensation or feeling to the part to which it is distributed. The other root gives the power of motion.

Q. What are the different functions of the roots of the spinal nerves?

174. In PARALYSIS, (palsy,) where feeling is destroyed, one root (the posterior) of the nerve is affected. Where motion alone is lost, the anterior root of the nerve is diseased.

Q. What effect has disease upon the roots of the spinal nerves?

Remark. — In the lower cavity of the body, (§ 20,) upon each side of the spinal column, are situated small masses of nervous matter, called *gan'gli-ons*. These are connected with each other and with the spinal nerves. They likewise send multitudes of minute threads to the blood vessels of every part of the body. This is called the *gan-gli-on'ic*, or *sym-pa-thet'ic* nerve, (Fig. D, p. 76.)

Q. What nerve is named in the remark? Describe it.

REVIEW.

167, 168, 169, 170, 171, 174.	<i>Anatomy</i>	} of the SPINAL CORD and NERVES.
169, 172, 173.	<i>Physiology</i>	
174.	<i>Hygiene</i>	

Review by Questions. — What can you state of the spinal cord? How are the nerves divided? What can you tell of the cranial nerves? What is said of paralysis? What can you say of the sympathetic nerve?

REVIEW BY TOPICS. — Give the Anatomy of the spinal cord and nerves, the Physiology. the Hygiene. (See outline anatomical, Plate VIII.)

Fig. 59.

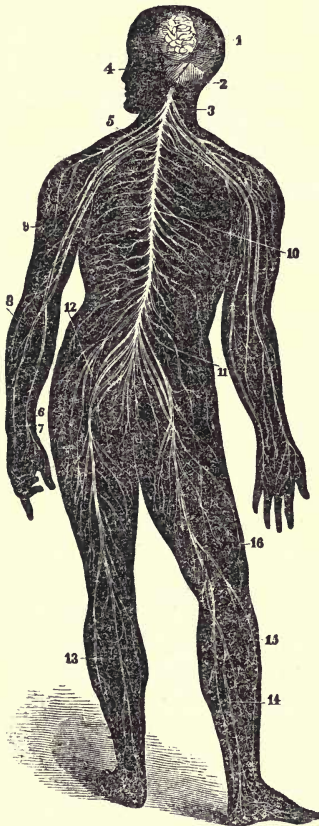


Fig. D.

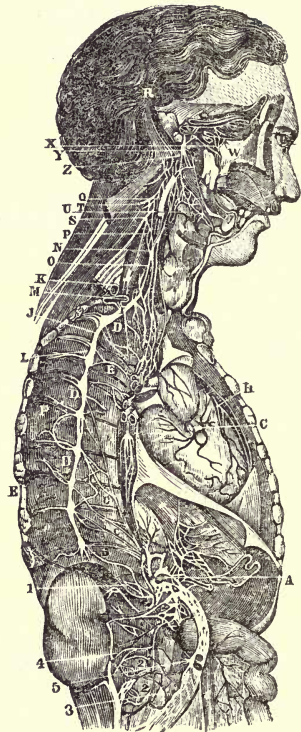


Fig. 59. A back view of the brain and spinal cord. 1. The cerebrum. 2. The cerebellum. 3. The spinal cord. 4. Nerves of the face. 5. The brachial plexus of nerves. 6, 7, 8, 9. Nerves of the arm. 10. Nerves that pass under the ribs. 11. The lumbar plexus of nerves. 12. The sacral plexus of nerves. 13, 14, 15, 16. Nerves of the lower limbs.

Fig. D. A beautiful representation of the sympathetic ganglia and their connection with other nerves. It is from the grand engraving of Manec, reduced in size. A, A, A. The semilunar ganglion and solar plexus, situated below the diaphragm and behind the stomach. This ganglion is situated in the region (pit of the stomach) where a blow gives severe suffering. D, D, D. The thoracic (chest) ganglia, ten or eleven in number. E, E. The external and internal branches of the thoracic ganglia. G, H. The right and left coronary plexus, situated upon the heart. I, N, Q. The inferior, middle, and superior cervical (neck) ganglia. 1. The renal plexus of nerves that surrounds the kidneys. 2. The lumbar (loin) ganglion. 3. Their internal branches. 4. Their external branches. 5. The aortic plexus of nerves that lies upon the aorta. The other letters and figures represent nerves that connect important organs and nerves with the sympathetic ganglia.

SYNTHETIC REVIEW OF THE CEREBRO-SPINAL AXIS.

154, 155, 156, 157, } 158, 159, 160, 154. } 167, 168, 169, 170, } 171, 174. . . . }	<i>Brain,</i> <i>Spinal cord and nerves,</i>	} ANATOMY	} of the CEREBRO SPINAL AXIS. (Fig. 59.)	
153, 161, 162. . . } 172, 173. . . . }	<i>Brain,</i> <i>Spinal cord and nerves,</i>			} PHYSIOLOGY
162, 163, 165. . . } 173, 174. . . . }	<i>Brain,</i> <i>Spinal cord and nerves,</i>			

Review by Questions. — What analysis can you give of the nervous apparatus? How is the brain divided? What can you say of the structure of the cerebrum? of the cerebellum? What can you tell of the anatomy of the spinal cord? of the cranial nerves? of the spinal nerves? What can you state of the nervous system of birds? of fishes? of insects? What can you say of the sympathetic nerve?

What can you tell of the physiology or use of the above-named parts?

How can these parts be developed? What can you say of the blood of the nervous system? of the education of the brain? of sleep? of sick rooms?

REVIEW BY TOPICS. — Give the Anatomy of the cerebro-spinal axis, the Physiology, the Hygiene. (Use outline anatomical, Plates I. and VIII.)

CHAPTER II.

175. THE Creator, in placing us in this world of so much beauty and grandeur, gave us organs to enjoy it. These works of God are perceived through the *senses*.

LESSON XVI.

176. There are FIVE SENSES — *feeling*, or touch, *taste*, *smell*, *vision*, or sight, and *hearing*.

Q. How many senses? What are they?

FEELING, OR TOUCH.

177. FEELING resides in the skin generally; but it is most acute in the ends of the fingers, palms of the hands, and particularly the lips.

Q. Where does feeling reside? Where is it most acute?

178. By use, this sense becomes more acute. For this reason, blind persons learn to know so accurately different objects.

Q. What effect has use upon feeling? Is this sense of great use to blind persons?

TASTE.

179. TASTE not only gives us physical pleasure, but has an influence upon our health; for upon it we considerably depend in distinguishing proper food.

Q. What is the use of taste?

Remark.—The camel trusts to this sense alone to distinguish its food.

Q. Of what use is taste to the camel?

180. The tongue is the seat of taste. A particular nerve called the *gust'a-to-ry*, or nerve of taste, is the agent of this sense. (Fig. 61.)

Q. Where is taste situated? What is the name of the nerve of taste?

Fig. 60.



Fig. 60. Distribution of the fifth pair of nerves. 1. The eye. 2. The upper jaw. 3. The tongue. 4. The lower jaw. 5. The fifth pair of nerves. 6. Branch to the eye. 7. Branch to the upper jaw. 8. Branch to the tongue and lower jaw. This is the nerve of taste.

181. Taste, though intended to give us pleasure, is often abused by tobacco, intoxicating drinks, and food spiced to excess.

Q. For what was taste intended? How is it abused?

SMELL.

182. SMELL has its seat in the passages of the nose (Fig. 61.)

Q. Where is the seat of smell?

183. The NOSE is formed of bone, cartilage, (gristle,) and lined with a very delicate membrane. (Fig. 61.)

Q. Describe the nose.

184. Upon this membrane is spread the *ol-fact'o-ry*, or nerve of smell. (Fig. 61.)

Q. What is the name of the nerve of smell?

Fig. 61.

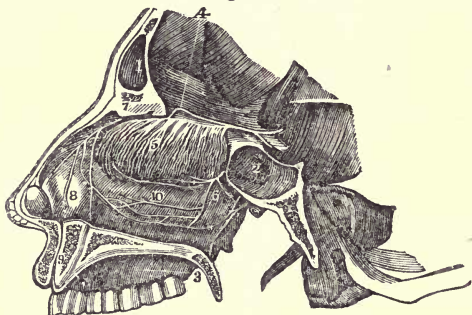


Fig. 61. A side view of the passage of the nostrils and the distribution of the nerve of smell. 4. The nerve of smell. 5. The fine and curious divisions of this nerve on the membrane of the nose. 6. A branch of the fifth pair of nerves.

185. Smelling increases our enjoyment, though it is not essential to our existence. It aids us in distinguishing useful from hurtful food.

Q. Is the sense of smell essential to life? Wherein does it aid us?

Remark. — Some of the lower order of animals, as the hound, has this sense more acute than man.

Q. Name the inferior animals that have this sense more acute than man?

REVIEW.

177, 180, 183, 184.	Anatomy	of organs of touch, taste, and smell.	} SENSE.
176, 177, 179, 182.	Physiology	of organs of touch, taste, and smell.	
178, 181, 185.	Hygiene	of organs of touch, taste, and smell.	

Review by Questions. — How many senses are there? Can you name them? What can you say of feeling? What of taste? What of smell?

REVIEW BY TOPICS. — Give the Anatomy of the organs of touch, taste, and smell, the Physiology, the Hygiene.

LESSON XVII.

186. Of the senses, none is more useful and adds more to our happiness than *vision*, or sight. The organs from which we receive so much pleasure are the eyes.

THE EYES.*

187. The eye is composed of many parts — as the *coats*, *hu'mors*, *mus'cles*, &c. (Fig. 62.)

Q. Of what is the eye composed?

188. The COATS are three in number — the *corn'e-a* and *scl'e-rot'ic*, the *cho'roid*, and the *ret'i-na*. (Fig. 62.)

Q. How many coats has the eye? What are they?

* Illustrate this lesson by using the eyes of animals, diagrams, and the blackboard.

189. The CORNEA is the outer front part of the eye. In health, this coat is covered with a fluid that gives the eye its sparkling brilliancy. (Fig. 62.)

Q. Describe the cornea. With what is it covered ?

190. The SCLEROTIC is the external and principal coat. It gives form to the eye. It is sometimes called the "white of the eye," from its chalky appearance. (Fig. 62.)

Q. Describe the sclerotic coat. What gives form to the eye ? What is it sometimes called ?

Fig. 62.

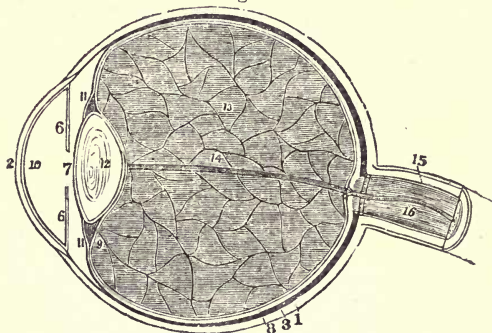


Fig. 62. A section of the globe of the eye. 1. The sclerotic coat. 2. The cornea. (This connects with the sclerotic coat by a bevelled edge.) 3. The choroid coat. 6, 6. The iris. 7. The pupil. 8. The retina. 10, 11, 11. Chambers of the eye that contain the aqueous humor. 12. The crystalline lens. 13. The vitreous humor. 15. The optic nerve. 16. The central artery of the eye.

Remark. — In the shark, that lives at great depths in the ocean, the sclerotic coat is bone. This provision is to resist the great pressure of the water.

Q. What is said of the eye of the shark ?

191. The CHOROID coat is very thin. It is a net of

blood vessels. Its inner surface is dark colored. (Fig. 62.)

Q. Describe the choroid coat.

Remark. — In the cat this coat is light colored, which gives a wild and yellow glare to pussy's eyes when seen in the dark.

Q. What causes the wild appearance of the eye of a cat in the dark?

192. The RETINA is the expansion of the optic nerve, (nerve of vision.) It is the immediate seat of sight. The impression made by objects upon the retina is conveyed to the brain. (Fig. 62.)

Q. Describe the retina and its use.

193. There are three humors within the coats of the eye — *a'que-ous*, *crys'tal-line*, and *vit're-ous*. (Fig. 62.)

Q. How many humors has the eye? What are their names?

194. The AQUEOUS humor is fluid. It occupies the fore part of the eye, behind the cornea. (Fig. 62.)

Q. What is the aqueous humor? Where is it situated?

195. The CRYSTALLINE humor lies in the central part of the eye. It is oval, dense, and composed of layers like an onion. (Fig. 62.)

Q. Describe the crystalline humor.

196. The VITREOUS humor occupies the larger and back portion of the eye. (Fig. 62.)

Q. What is said of the vitreous humor?

197. The IRIS is a curtain across the eye, before the crystalline humor. It has an opening in the centre, called the *pu'pil*. The iris gives the blue, black, or gray color to the eye. (Fig. 62.)

Q. Where is the iris situated? What is the opening in the centre called? What does the iris give?

198. The eye of a bee or fly is composed of many thousand *facets*; each of which has a nerve, so that it is an independent eye. Hence a bee or fly can see in all directions without turning the head. (Fig. 63.)

Q. What is said of the eye of a bee or fly?

Fig. 63.

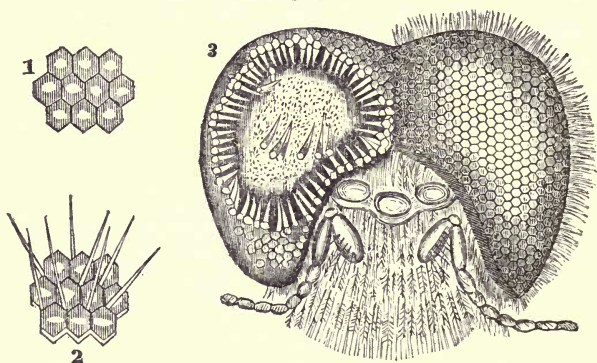


Fig. 63. The compound eye of a fly or bee. 1. The facets, or lenses, without hairs. 2. The same with hairs. 3. The conical form of the facets shown.

199. The *coats* give form to the eye; the *humors* change the direction of the rays of light that pass to the retina; the *iris* regulates the quantity of light that enters the eye. (Fig. 62.)

Q. What is the use of the coats of the eye? The humors? The iris?

200. The **MUSCLES** of the eye are six in number. They are small, and produce the movements of this organ.

Q. How many muscles has the eye, and what is their use?

201. The eye is protected from too great light, particles

of dust, and other substances by the eyebrows, eyelids, and eyelashes.

Q. What parts protect the eye ?

202. The tears also afford protection by keeping the eye moist, as well as aiding the removal of particles of matter.

Q. What is the use of tears ?

203. Vision is improved by practice, like the other senses ; but it requires care not to overtask the eye.

Q. How is sight improved ? What care should be used ?

204. The eye should be used in viewing objects at different distances, as nearsightedness may be caused by repeatedly, and for a long time, viewing small objects very near the eye.

Q. How should the eye be used ? How may nearsightedness be produced ?

205. The eye should be used in a moderate light, and should be frequently rested.

Q. What is said of light and rest to the eyes ?

REVIEW.

187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 200.	<i>Anatomy</i>	} of the EYE.
186, 189, 190, 192, 197, 198, 199, 200, 201, 202.	<i>Physiology</i>	
203, 204, 205.	<i>Hygiene</i>	

Review by Questions. — What are the parts that compose the eye ? What can you say of the structure and use of the coats of the eye ? What of the humors ? What of the muscles ? How is the eye protected ? How should it be used ?

REVIEW BY TOPICS. — Give the Anatomy of the eye, the Physiology, the Hygiene. (See outline anatomical, Plate X.)

LESSON XVIII.

206. HEARING, in utility, is scarcely inferior to that of sight. While we can see in only one direction at a

time, we can hear from all directions. While the eye is useless in the dark, and veiled by its own curtains during sleep, the *ear* is ever a faithful sentinel, warning us against danger.

Q. What is said of hearing?

THE EAR.

207. The EAR is composed of three parts — the *external*, the *middle*, and the *internal ear*. (Figs. 64, 65.)

Q. Of how many parts is the ear composed? What are they?

208. The EXTERNAL EAR is formed by cartilage, or gristle. This is covered by a delicate membrane, or skin. (Figs. 64, 65.)

Q. Describe the external ear.

209. A tube, or channel, leads from the external to the middle ear. This tube is always open. Its only protection against the entrance of insects is a very bitter wax, (*ce-ru'men*,) formed at the roots of fine hairs, with which it is lined. (Figs. 64, 65.)

Q. What is said of the tube between the external and middle ear? Where is the earwax formed, and what is one of its uses?

210. The MIDDLE EAR is a cavity called the *tym'pa-num*, (drum.) (Fig. 65.)

Q. What is the middle ear?

211. The external part of the middle ear is formed by a membrane called the drum, (*mem'bra-na tym'pa-ni*.) It is the bottom of the tube leading from the external to the middle ear, and forms a division between them. (Fig. 65.)

Q. Where is the drum, or *membrana tympani*, situated? What is its use?

Remark.— A small nerve crosses this membrane, which connects with a nerve that is distributed to the teeth. This is the cause of the unpleasant sensation of the teeth when a file is drawn across iron or steel.

Q. What causes the unpleasant sensation of the teeth when filing iron ?

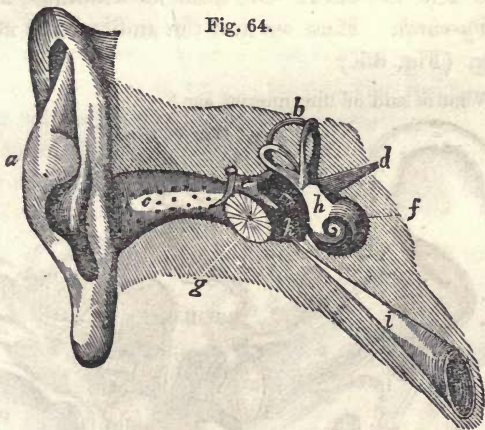


Fig. 64.

Fig. 64. External and middle ear. *a*. The external ear. *c*. The channel from the external to the middle ear. *g*. The drum of the ear. *k*. The middle ear. *e*. The bones of the middle ear. *i*. The tube from the throat to the middle ear. *b, f, h*. The internal ear. *d*. The auditory nerve.

212. In the MIDDLE EAR are four of the smallest bones of the body. They form a chain of connection between the external and internal ear. (Fig. 65.)

Q. What is said of the small bones in the middle ear ?

213. A tube leads from the middle ear to the throat. Hence, when we wish to hear distant or faint sounds, we usually open the mouth. (Figs. 64, 65.)

Q. Why do we open the mouth to hear a distant or faint sound?

Remark. — The closing of this tube by enlarged tonsils and sore throat causes difficulty of hearing.

Q. What is one cause of defective hearing?

214. The INTERNAL ear, from its windings, is called the *lab'y-rinth*. Here we find the auditory, or nerve of hearing. (Fig. 65.)

Q. What is said of the internal ear?

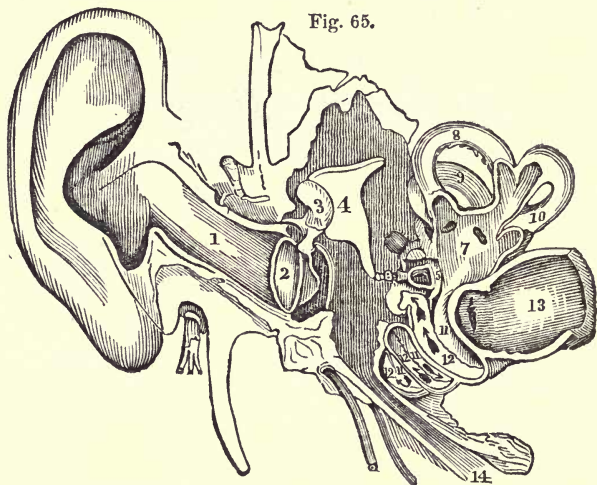


Fig. 65. A view of all the parts of the ear. 1. The tube that leads to the internal ear. 2. The drum of the ear. 3, 4, 5. The bones of the ear. 7, 8, 9, 10, 11, 12. The internal ear. 13. The auditory nerve. 14. The channel from the middle ear to the throat, (Eustachian tube.)

215. Waves or vibrations of air are collected by the external ear and conveyed to the middle ear, and across it, by the chain of bones, to the internal ear. An impression is made on the nerve of hearing in so delicate a

manner as to enable us to perceive minute variations of sound. (Fig. 65.)

Q. How are the waves of air or sound conveyed to the middle ear?

216. This sense can be improved by culture or training; and, in order to hear perfectly, all the parts that aid in hearing should be healthy.

Q. What is necessary to perfect hearing?

Remark. — 1. It is wrong to put the heads of pins into the ear, as they may cause inflammation. The wax can be softened by dropping into the tube some oil; and in a few hours remove it by ejecting warm soapsuds into the ear.

2. When worms and insects find their way into the tube of the external ear, they can usually be driven out by dropping in warm olive oil.

Q. What is said in the first remark? in the second?

REVIEW.

207, 208, 209, 210, 211, 212, 213, 214.	<i>Anatomy</i>	} of the EAR.
211, 212, 213, 215.	<i>Physiology</i>	
216.	<i>Hygiene</i>	

Review by Questions. — Can you name the parts of the ear? What can you say of the structure of the external ear? What can you state of the anatomy of the middle ear? What of the internal ear? Can you tell the uses of the external, middle, and internal ear? How is sound produced? How are we able to perceive sound? What can you say of the cultivation of this sense? How can disease of the ear be prevented?

REVIEW BY TOPICS. — Give the Anatomy of the ear, the Physiology, the Hygiene. (See outline anatomical, Plate X.)

Fig. 66.

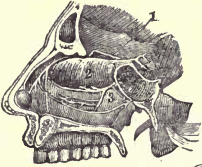


Fig. 67.

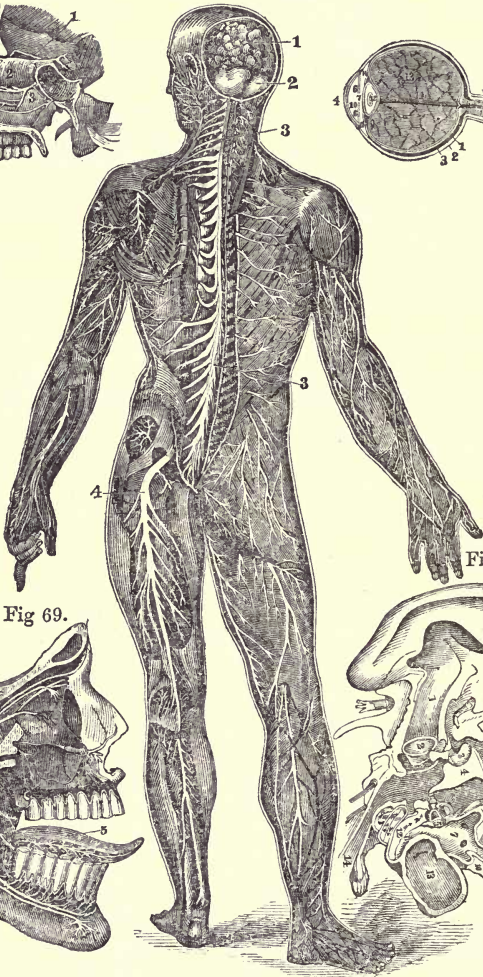


Fig. 68.

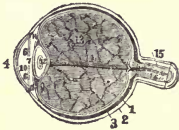


Fig. 69.

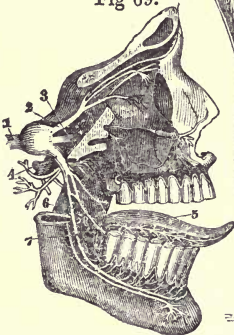


Fig. A.



Fig. 66. A representation of the nose. 1 The olfactory nerve. 2. The ramification of the olfactory nerve. 3. A nerve of feeling.

Fig. 67. A representation of the brain, spinal cord, and spinal nerves. 1. The large brain, (cerebrum.) 2. The small brain, (cerebellum.) 3, 3. The spinal cord. 4. The sciatic nerve.

Fig. 68. Section of the eye. 1, 2, 3. The coats of the eye. 4. The cornea. 6, 6. The iris. 7. The pupil. 10, 11. The aqueous humor. 12. The crystalline humor. 13. The vitreous humor. 15. The optic nerve.

Fig. 69 represents the nerves of sensation of the face. 1. The nerve of sensation. 2. The branch to the eye. 3. The branch to the upper jaw. 4. The branch to the lower jaw. 5. The tongue. 6. The *nerve of taste*. 7. The branch to the lower jaw.

Fig. A. The ear. 1. The external opening of the ear. 2. The drum of the ear. 3, 4, 5, 6. The small bones of the ear. 7, 8, 9, 10, 11, 12. The internal ear. 13. The nerve of hearing. 14. The Eustachian tube.

SYNTHETIC REVIEW OF THE NERVOUS APPARATUS

154, 155, 156, 157, 158, 159, 160.	<i>Brain,</i>	CEREBRO-SPINAL SYSTEM,	}	ANATOMY	OF THE NERVOUS APPARATUS. (Figs. 66, 67, 68, 69, A.)
167, 168, 169, 170, 171. . . .	<i>Spinal cord and nerves,</i>				
177, 180, 183, 184.	<i>Feeling, Taste, and Smell,</i>				
187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 200.	<i>Eye,</i>	SENTIENT SYS- TEM,	}		
207, 208, 209, 210, 211, 212, 213, 214.	<i>Ear,</i>				
153, 161, 162.	<i>Brain,</i>			CEREBRO-SPINAL SYSTEM,	
172, 173.	<i>Spinal cord and nerves,</i>				
177, 179, 182.	<i>Feeling, Taste, and Smell,</i>				
189, 190, 192, 197, 198, 199, 200, 201, 202,	<i>Eye,</i>	SENTIENT SYS- TEM,	}		
211, 212, 213, 215.	<i>Ear,</i>				
162, 163, 165.	<i>Brain,</i>			CEREBRO-SPINAL AXIS,	}
174.	<i>Spinal cord and nerves,</i>				
178, 181, 185.	<i>Feeling, Taste, and Smell,</i>				
203, 204, 205.	<i>Eye,</i>	SENTIENT SYS- TEM,	}		
216.	<i>Ear.</i>				

Review by Questions. — How is the nervous apparatus divided? What can you say of the anatomy of the brain? of the spinal cord? of the cranial nerves? of the spinal nerves? of the sympathetic nerve? What can you tell us of the nervous system of birds? of fishes? of insects? What can you state of the structure of the organs of touch? of taste? of smell? of seeing? of hearing?

What can you say of the physiology or use of each of the above-named parts of the nervous system?

What can you say of the education of these parts? of the preservation of health of each part?

REVIEW BY TOPICS. — Give the Anatomy, human and comparative, of the nervous apparatus, the Physiology, the Hygiene. (Use outline anatomical, Plates I., VIII., and X.)

PART III.

217. IN this part the LOCOMOTIVE and PROTECTIVE APPARATUS will be described. This includes the *bones*, *muscles*, and *skin*, or the systems that form the walls that enclose the organs described in Parts I. and II. (Figs. 2,3.)

Q. What apparatus will be described in Part III.? What systems under this apparatus?

CHAPTER I.

218. The OSSEOUS or bony system will be described in this chapter. In man and the inferior animals, the bones are covered by muscles and skin; while in lobsters, crabs, &c., their bony framework is on the outside.

Q. What system is described in Chapter I. How are the bones arranged in man? In lobsters?

LESSON XIX.

219. There are two hundred and eight bones in the human body besides the teeth. These, for convenience, are divided into the bones of the *head*, *trunk*, *upper* and *lower extremities*. (Figs. 85, 98.)

Q. How many bones in the human body? How divided?

BONES OF THE HEAD.*

220. The bones of the HEAD include those of the *crā'ni-um*, (skull,) *ear*, and *face*, or all the bones above the neck. Figs. 65, 70.)

Q. What do the bones of the head include ?

221. The CRANIUM has eight bones. These interlock like the teeth of two saws brought together. This union is called a *sut'ure*. (Fig. 70.)

Q. How many bones in the cranium ? How are they united ? What is this union called ?

Fig. 70.

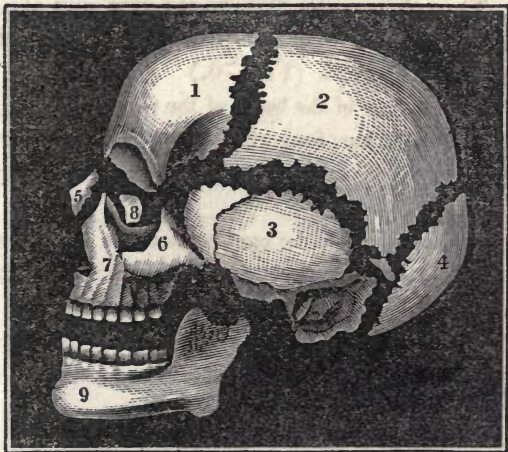


Fig. 70. The bones of the head. 1. Frontal bone. 2. The parietal bone. 3. The temporal bone. 4. The occipital bone. 5. The nasal bone. 6. The malar bone. 7. The upper jaw. 8. The os unguis. 9. The lower jaw.

222. The upper part of the head is an arch, or dome.

* Let the skull bones of animals be used to illustrate this lesson, in connection with plates and the blackboard. (See *Preface*.)

This form gives great security to the parts within this cavity. (Fig. 70.)

Q. What is the form of the cranium? What is the use of this form?

223. The bones of the cranium are thin, and very easily broken; for this reason, children should never be struck upon the head. (Fig. 70.)

Q. Why should children never be struck upon the head?

224. The FACE is composed of fourteen bones—two single, the other twelve in pairs. (Fig. 70.)

Q. How many bones in the face? How arranged?

225. These bones give form to the face, and also protection to the parts that are placed in and about the lower part of the head. (Fig. 70.)

Q. What is the use of the bones of the face?

226. The EAR has four very small bones. They are enclosed in a cavity formed by the bones of the cranium. (Figs. 65, 70.)

Q. How many bones in the ear? Where are they placed?

227. At the base of the tongue is a small bone shaped like the letter *U*, called the *hy'oid*. (Fig. 46.)

Q. What is said of the bone at the base of the tongue?

REVIEW.

218, 219, 220, 221, 223, 224, 226, 227.	<i>Anatomy</i>	} of the HEAD.
222, 225.	<i>Physiology</i>	
223.	<i>Hygiene</i>	

Review by Questions.—How is the protective apparatus divided? How is the osseous system divided? How are the bones of the head divided? What can you say of the bones of the cranium? of the ear? of the face?

REVIEW BY TOPICS.—Give the Anatomy of the bones of the head, the Physiology, the Hygiene. (See outline anatomical, Plates I. and II.)

LESSON XX.

228. While the arrangement of the bones of the skull is a proof of the beautiful economy of Nature in giving great strength with a small amount of material, other bones, as those of the *trunk*, protect lifegiving organs and also possess freedom of motion.

Q. What is said of the bones of the head? Of the trunk?

BONES OF THE TRUNK.*

229. The bones of the TRUNK include those of the *spinal column*, (back bone,) the *tho'rax*, (chest,) and the *pel'vis*, (basin.) (Figs. 85, 98.)

Q. Name the bones of the trunk.

230. The SPINAL COLUMN is composed of twenty-four bones. These are so arranged that a tube or canal is formed through the whole column (Figs. 2, 71, 85, 98.)

Q. How many bones in the spinal column? How are they arranged?

231. Seven of these are called *cer'vi-cal* (neck) bones, twelve *dor'sal* (back) bones, five *lum'bar* (loin) bones.

Q. How are the bones of the spinal column divided?

232. Among the inferior animals, as the lion, we find an increased number of dorsal bones. Among birds, the number of neck bones is increased and the number of dorsal bones are diminished, while there are no loin bones. Among most reptiles, as the snake, there are no

* Use the ribs and spinal bones of animals to illustrate the bones of the trunk, in connection with outline diagrams and the blackboard.

neck or loin bones, while the dorsal bones are very much increased in number. The same is true with most fishes.

Q. What is said of the spinal bones of the inferior animals? Of birds? Of snakes? Of fishes?

233. Between each bone of the spinal column is a substance called cartilage, (gristle.) By the yielding of these cartilages, the body, to a certain extent, can be bent in all directions. (Fig. 71.)

Q. What is found between the bones of the spinal column? What is its use?

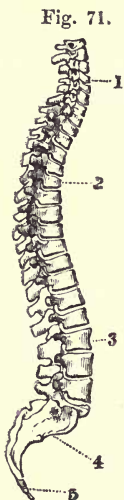


Fig. 71. 1, 2, 3. The spinal column. 4, 5. The sacrum and coccyx bones of the pelvis.

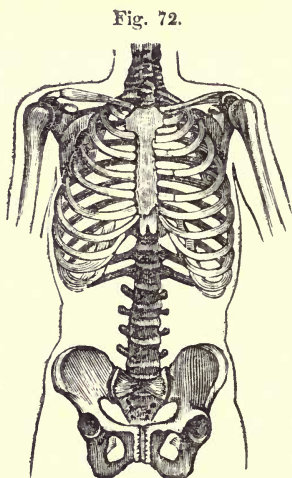


Fig. 72. The chest and pelvis.

Observation. — Persons whose business requires them to stand during the day are shorter at night, by com-

pression of the cartilages, than in the morning ; but during sleep, the cartilages, by elasticity, regain their thickness.

Q. Why are persons that stand during the day shorter at night than in the morning ?

234. To prevent distorted or curved spines, children should walk and sit erect ; also frequently change their position. If their school desks require the spine to be bent, they should alter their position often by standing erect.

Q. What should children frequently do to prevent distorted spines ?

235. The THORAX is composed of the *ster'num*, (breast bone,) twenty-four ribs, and twelve bones of the spine. (See Lesson VII.)

Q. Of what is the thorax composed ?

236. The PELVIS is composed of four large bones. The back part of this basin is formed of two bones, which terminate the spinal column. (Figs. 71, 72, 85, 98.)

Q. How many bones in the pelvis ? What bones form the back part of the pelvis ?

237. Among reptiles and fishes, the number of pieces in the terminating bone of the spine is much increased, forming the tail. (Figs. 71, 87.)

Q. What is said of the terminal bones of the spine of reptiles ?

238. The pelvis gives support to the spinal column and digestive organs. It also furnishes the means of attachment of the lower extremities. (Figs. 72, 85, 98.)

Q. What supports the spine and digestive organs ? To what are the lower extremities attached ?

REVIEW.

229, 230, 231, 232, 233, 235, 236, 237.	<i>Anatomy</i>	} of the TRUNK.
228, 233, 238.	<i>Physiology</i>	
228, 234.	<i>Hygiene</i>	

Review by Questions. — How are the bones of the trunk divided? What can you say of the spinal column in man? in birds? in reptiles? How are distorted spines produced? how prevented? What can you tell of the thorax? How is the pelvis formed? What is its use?

REVIEW BY TOPICS. — Give the Anatomy of the trunk, the Physiology, the Hygiene. (See outline anatomical, Plates I. and II.)

LESSON XXI.

239. While the bones of the head, chest, and spine are of importance to the safety of life, the bones of the *upper extremities* exceed all others or any instrument of art in the variety of motion and uses to which they can be put. (Figs. 85, 98.)

Q. What is said of the bones of the upper extremities?

THE UPPER EXTREMITIES.*

240. The bones of the UPPER EXTREMITIES comprise the *shoulder*, the *arm*, the *wrist*, and *hand*. (Figs. 73, 74, 75, 76, 85, 98.)

Q. Name the bones of the upper extremities.

241. The SHOULDER embraces the *scap'u-la*, (shoulder blade,) and *clav'i-cle*, (collar bone.) (Fig. 85.)

Q. What bones are embraced in the shoulder?

242. The SCAPULA is a broad, thin bone, and lies embedded in the fleshy part of the back. It can be moved in all directions. (Fig. 85.)

* Illustrate this lesson by using the bones of animals, outline plates, and the blackboard.

Q. Describe the scapula. Are its movements limited?

243. The CLAVICLE is united to the *sternum* (breast bone) and scapula. It acts as a brace in keeping back the shoulders. (Figs. 72, 85, 98.)

Q. Describe the clavicle. What is its use?

Fig. 73.



Fig. 74.

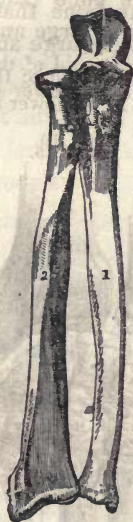


Fig. 73. The shaft of the humerus.

Fig. 74. 1. The body of the ulna. 2. The shaft of the radius.

244. In birds the clavicle is large and strong; while in fourfooted animals, as the horse, it is wanting. (Fig. 86.)

Q. What is said of the clavicle in birds? In the horse and other fourfooted animals?

245. The ARM is composed of three bones — the hu-

me-rus, above the elbow, and the *ra'di-us* and *ul'na*, below the elbow. By a nice adaptation of the bones below the elbow, they can rotate or twist upon each other. (Figs. 73, 74, 85, 98.)

Q. What is said of the bone above the elbow? Of the bones below the elbow?

246. In the lower animals, as the horse and ox, there is but one bone that corresponds with the radius and ulna; this is large and firm. (Fig. 88.)

Q. What is said of the bones that correspond with the ulna and radius in the lower animals?

Fig. 75.

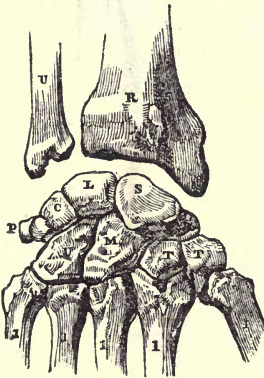


Fig. 75. U. The ulna. R. The radius. S, L, C, P, T, T, M, U. The carpal bones. 1, 1, 1, 1, 1. The metacarpal bones of the thumb and fingers.

Fig. 76.

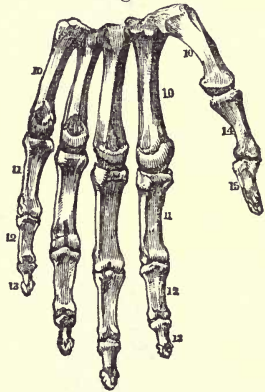


Fig. 76. 10, 10, 10. The metacarpal bones of the hand. 11, 11. First range of finger bones. 12, 12. Second range of finger bones. 13, 13. Third range of finger bones. 14, 15. Bones of the thumb.

247. The WRIST (carpus) consists of eight irregular bones. They are closely bound together, and have but little motion. (Figs. 75, 85, 98.)

Q. What is said of the wrist?

248. The HAND (metacarpus) has five bones. To these are united the fourteen bones of the fingers and thumbs, (*pha-lan'ges.*) (Figs. 75, 76, 85, 98.)

Q. Describe the hand.

249. In the inferior animals there are but one, or at most two bones that correspond with the fingers of man. These are only used to support the animals.

Q. What is said of the finger bones in animals?

250. The bones of the fingers and thumb are so arranged that we can grasp a body of any shape with great firmness. Owing to the different length of the fingers, we can grasp with greater ease a round body. (Fig. 76.)

Q. What is said of the use of the thumb and fingers?

REVIEW.

240, 241, 242, 243, 244, 245, 246, 247, 248, 249.	<i>Anatomy</i>	} of the UPPER EXTREMITIES.
239, 242, 243, 245, 247, 249, 250.	<i>Physiology</i>	
	<i>Hygiene</i>	

Review by Questions. — What do the upper extremities comprise? What can you say of the shoulder? of the scapula? of the clavicle? What can you tell of the arm? What can you relate of the wrist? What can you state of the hand?

REVIEW BY TOPICS. — Give the Anatomy of the upper extremities, the Physiology, the Hygiene. (See outline anatomical, Plates I. and II.)

LESSON XXII.

251. The bones of the *lower* are larger than those of the upper extremities. Their motion is not so varied; yet they support the body; and by them we are able to ramble the fields and forests. (Figs. 85, 98.)

Q. What is said of the bones of the lower extremities?

THE LOWER EXTREMITIES.*

252. The bones of the LOWER EXTREMITIES comprise those of the *leg* and those of the *foot*. (Figs. 77, 78, 79.)

Q. Name the bones of the lower extremities ?

Fig. 77.

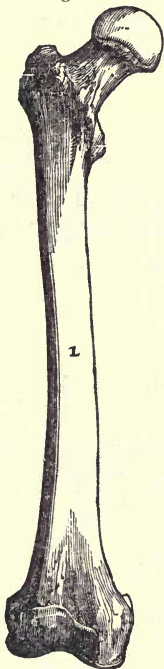


Fig. 78.

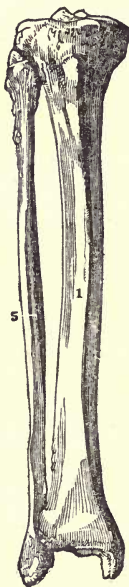


Fig. 77. 1. The shaft of the femur, (thigh bone.)

Fig. 78. 1. The tibia. 5. The fibula.

253. The LEG contains the *fe'mur*, (thigh bone,) the

* Illustrate this lesson by using the bones of animals and birds, with outline diagrams and the blackboard.

tib'i-a and *fib'u-la*, (shin bones,) and *pa-tel'la*, (knee pan.) (Figs. 77, 78, 98.)

Q. Name the bones of the leg.

254. The bones of the leg, with the exception of the patella, are round, and larger at the extremities than at the centre. (Figs. 77, 78, 85, 98.)

Q. What is said of the shape of the bones of the leg?

Remark.—The bones of the leg correspond with those of the arm.

Q. Do the bones of the leg and arm correspond?

255. The foot contains the *tar'sus*, *met-a-tar'sus*, and *pha-lan'ges*, (toes.) (Figs. 79, 80.)

Fig. 79.



Fig. 79. A representation of the upper surface of the bones of the foot. 1, 2, 3, 4, 5, 6, 7, 8. The bones of the tarsus. 9, 9, 9. The metatarsal bones. 10. The first bone of the great toe. 11. The second bone. 12, 13, 14. Three ranges of bones, forming the small toes.

256. The TARSUS (ankle bones) are seven in number. They are bound together like those of the wrist, and have but little motion. (Figs. 79, 80.)

Q. What is said of the tarsus?

257. The METATARSUS contains five bones. These, with the tarsal bones, form the arch of the foot. By the form of the foot, jars or concussions of the brain are prevented in running and leaping. (Figs. 79, 80.)

Q. How many metatarsal bones? What is the form of the foot? What does this form prevent?

258. The PHALANGES (bones of the toes) are fourteen in number. These bones are smaller than those of the fingers, and their motion is more limited; yet persons with no hands have been able to use scissors, pencil, and knife with the toes. (Figs. 79, 80.)

Q. How many toes are there? What is said of their size? Their motion? Their use?

Fig. 80.

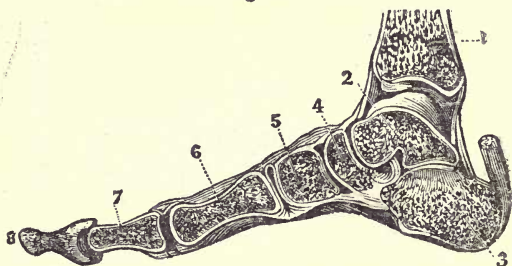


Fig. 80. A side view of the bones of the foot, showing its arched form. The arch rests upon the *heel* behind, and the *ball* of the toes in front. 1. The lower part of the tibia. 2, 3, 4, 5. Bones of the tarsus. 6. The metatarsal bone. 7, 8. The bones of the great toe. These bones are so united as to secure a great degree of elasticity, or spring.

REVIEW.

252, 253, 254, 255, 256, 257, 258.	Anatomy	} of the LOWER EXTREMITIES.
251, 258.	Physiology	
257.	Hygiene	

Review by Questions. — What bones do the lower extremities comprise? What can you say of the bones of the leg? What can you tell of the foot? of the tarsus? of the metatarsus? of the phalanges?

REVIEW BY TOPICS. — Give the Anatomy of the lower extremities, the Physiology, the Hygiene. (See outline anatomical, Plates I. and II.)

LESSON XXIII.

259. The bones, like other parts of the body, are composed of solids and fluids, as well as of different elements, or atoms of matter. The relative proportions of solids and fluids vary at different periods of life, and so do the chemical elements that enter into their *composition*.

Q. What is said of the composition of bones?

COMPOSITION OF BONES.*

260. The bones are surrounded by a thin, firm membrane, called *per-i-os'te-um*.

Q. With what are the bones surrounded?

Remark. — In *felon* and *fever sore*, the disease commences in the periosteum. An early opening is the best treatment.

Q. What is the best treatment of felon and fever sore?

261. The bones are composed of cartilage and salts of lime.

Q. Of what are the bones composed?

Remark. — The cartilage contains *gel'a-tin*, ("jelly,") while the salts are the carbonate and phosphate of lime.

Q. What does cartilage contain? What salts exist in the bones?

Experiments. — 1. To show the materials that enter into the composition of bones, take one and lay it upon the fire. The heat will destroy the gelatin, and the bone will become white and brittle.

* Illustrate this lesson by performing the experiments and using the dry and fresh bones of animals.

2. Take another bone and put it into a weak solution of chloric acid, and in a few days the salts of lime will be removed, and the cartilage that remains can be knotted or twisted at pleasure.

Q. Give the experiments in reference to the composition of bones. What do these experiments snow ?

Fig. 81.



Fig. 82.



Fig. 81. The position assumed when the seat is of proper height and the feet supported.

Fig. 82. The position a child naturally assumes when the seat is so high that the feet are not supported.

262. In early life the cartilage, or soft parts of the bone, exists in great quantity. In old age, the salts of lime are most abundant. In children, the bones are therefore more easily bent or distorted than in old age, while in old age they are easily broken.

Q. At what period of life is gelatin most abundant? Why do

the bones of children bend more easily than aged persons? Why are the bones of the aged easily broken?

Remarks. — 1. Young children should not stand a long time, as the bones of the leg bend easily, producing crooked limbs.

2. Their clothing should be loose about the chest, as the ribs are not only small, but soft and yielding, in childhood.

3. The seats of small children should be low, so that their feet may be supported. (Fig. 81.)

4. The back of their seats should be convex or curved towards the body, and reach no higher than the shoulder blades, so as to support the *loins*, or “small of the back.” (Fig. 81.)

Q. What is the first remark relating to the bones of children? The second? The third? The fourth?

REVIEW.

- | | | |
|--------|-------------------|--------------------------------|
| 260. . | <i>Anatomy</i> | } of the COMPOSITION OF BONES. |
| 261. . | <i>Physiology</i> | |
| 262. . | <i>Hygiene</i> | |

Review by Questions. — What can you say of the periosteum? of felons and fever sores? What can you tell of the composition of the bones? State the experiments. What can you say of the clothing and seats for children?

REVIEW BY TOPICS. — Give the composition of the bones, their Physiology, their Hygiene.

LESSON XXIV.

263. To secure freedom of motion, the divine Framer of our body made it of several pieces instead of one solid bone. The union of these pieces is called a *joint*.

THE JOINTS.*

264. The JOINTS are of two kinds—*immovable* and *movable*.

Q. How many kinds of joints? What are they?

265. In an IMMOVABLE joint there is a direct union of the bones, as in the skull, face, &c. (Fig. 70.)

Q. Describe an immovable joint.

Fig. 83.

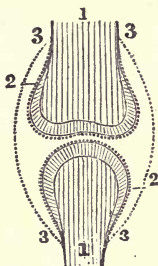


Fig. 84.

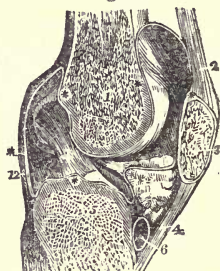


Fig. 83. The relative position of the bones, cartilages, and synovial membrane in a joint. 1, 1. The extremities of two bones that concur to form a joint. 2, 2. The cartilages that cover the end of the bones. 3, 3, 3, 3. The synovial membrane, which covers the cartilage of both bones, and is then doubled back from one to the other. It is represented by the dotted lines.

Fig. 84. A vertical section of the knee joint. 1. The femur. 3. The patella. 5. The tibia. 2, 4. The ligaments of the patella. 6. The cartilage of the tibia. 12. The cartilage of the femur. * * * *. The synovial membrane.

266. In MOVABLE joints, the surfaces of the bones do not come in contact; but the ends of the bones are

* Illustrate this lesson by using the joints of animals, by diagrams and the blackboard.

tipped with cartilage, (gristle,) and they are bound together by bands called *lig'a-ments*. (Figs. 85, 98.)

Q. Describe the union of a movable joint.

267. Covering the cartilages and lining the ligaments is a closed sac called *syn-o'vi-al mem'brane*, which contains a glairy fluid called *syn-o'vi-a*, (joint water.) This fluid lessens the friction of the joints as oil does in machinery. (Figs. 83, 84.)

Q. What is said of the synovial membrane? Of the synovia?

Remark. — 1. The synovial membrane, as a closed sac, can be illustrated by the lining membrane of an egg shell.

2. When joints are sprained or inflamed, the "best healing salve" is rest. This should be applied as soon as the joint is injured, and should be continued until the injured part recovers.

3. When the joints of animals are injured, they should be permitted to rest until restored.

Q. How can the synovial membrane be illustrated? What is necessary when a joint is sprained? How should the injured joints of animals be treated?

REVIEW.

264, 265, 266, 267.	<i>Anatomy</i>	} of the JOINTS.
263, 266, 267.	<i>Physiology</i>	
267.	<i>Hygiene</i>	

Review by Questions. — How many kinds of joints? What can you tell of immovable joints? of movable joints? What can you say of sprained joints in man? in animals?

REVIEW BY TOPICS. — Give the Anatomy of the joints, the Physiology the Hygiene. (See outline anatomical, Plates I. and II.)

Fig. 85.

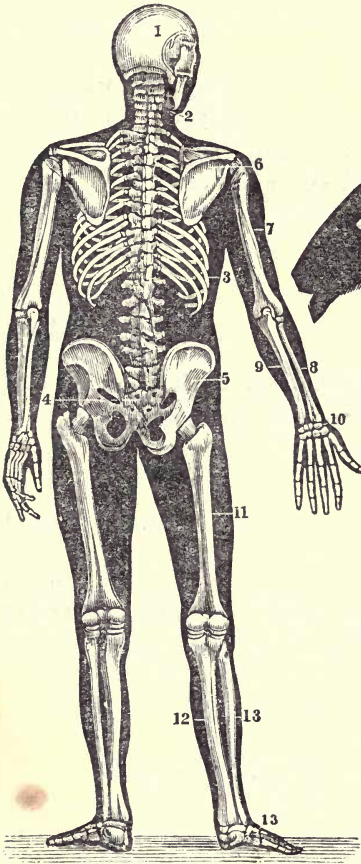


Fig. 86.

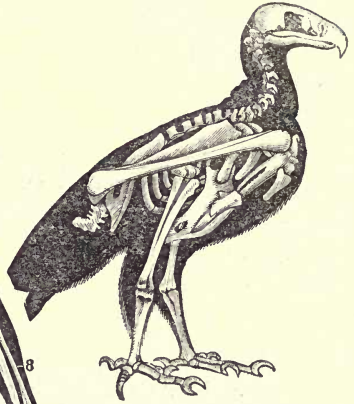


Fig. 87.

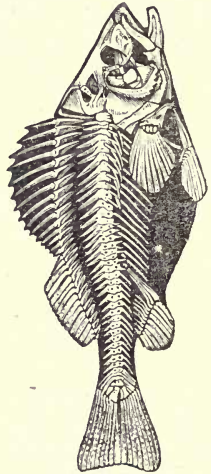


Fig. 85. Back view of human skeleton. 1. The head. 2, 2. The spinal column. 3. The ribs. 4. The sacrum. 5. The pelvis. 6. The scapula. 7. The humerus. 8. The radius. 9. The ulna. 10. The carpus. 11. The femur. 12. The tibia. 13. The fibula. 14. The tarsus.

Fig. 86. Skeleton of the vulture.

Fig. 87. Skeleton of the perch.

Fig. 88.

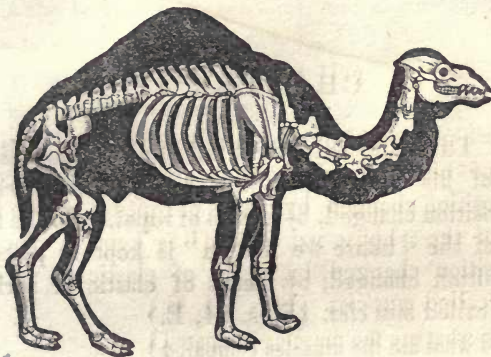


Fig. 88. Skeleton of the camel

SYNTHETIC REVIEW OF THE OSSEOUS SYSTEM.

218, 219, 220, 221, 223,	}	<i>Head,</i>	}	ANATOMY	of the OSSEOUS SYSTEM. (Figs. 85, 86, 87, 88.)	
224, 226, 227.						
229, 230, 231, 232, 233,	}	<i>Trunk,</i>				
235, 236, 237.						
240, 241, 242, 243, 244,	}	<i>Upper extremities,</i>				
245, 246, 247, 248, 249.						
252, 253, 254, 255, 256,	}	<i>Lower extremities,</i>				
257, 258.						
260.	}	<i>Composition of bones,</i>				
264, 265, 266, 267.						
222, 225.	}	<i>Head,</i>		PHYSIOLOGY		
233, 238.						
242, 243, 244, 245, 246,	}	<i>Upper extremities,</i>				
247, 249, 250.						
251, 258.	}	<i>Lower extremities,</i>				
261.						
263, 266, 267.	}	<i>Composition of bones,</i>				
223.						
228, 234.	}	<i>Head,</i>				HYGIENE
228, 234.						
257, 258.	}	<i>Trunk,</i>				
262.						
267.	}	<i>Upper extremities,</i>				
267.						
267.	}	<i>Lower extremities,</i>				
267.						
267.	}	<i>Composition of bones,</i>				
267.						
267.	}	<i>Joints,</i>				
267.						

Review by Questions. — What can you say of the anatomy of the bones of the head? of the trunk? of the upper extremities? of the lower extremities? What can you tell of the composition of the bones? What can you state of the joints?

What can you tell of the use of the above-named parts?

What can you state of the means to preserve the health of the osseous system?

REVIEW BY TOPICS. — Give the Anatomy of the osseous system, the Physiology, the Hygiene. (Use outline anatomical, Plates I. and II.)

CHAPTER II.

268. THE sailor boy would tell you that the masts and yards of his "floating house" are kept in place, and their position changed, by means of ropes. So the framework of the "house we live in" is kept in place, and the position changed, by means of elastic or springing organs called *mus'cles*. (Figs. 94, E.)

Q. To what are the muscles compared ?

LESSON XXV.

269. The mind directs some movements, as those of the arm. Other movements, as those of the heart and stomach, are not subject to the mind. Both, however, are produced by the action of *muscles*. (Figs. 94, E.)

Q. How are the movements directed ? What produces all movements ?

MUSCLES.*

270. The MUSCLES are composed of *fi'bres*, *fas'ci-æ*, and *ten'dons*. (Fig. 89.)

Q. Of what are the muscles composed ?

271. FIBRES are the small threads that compose the muscle. These form the swell, or belly, of the muscle. (Fig. 89.)

Q. Define fibre. What do they form ?

* Illustrate this lesson by using lean pork, boiled, or the drumstick of a fowl, with outline diagrams and the blackboard. (See *Preface*.)

272. The **FASCIA** is a thin, white membrane that surrounds the body, limbs, muscles, and also every fibre of all the muscles. (Figs. 89, 94, E, 100.)

Q. Describe the fascia.

273. The **TENDON**, or cord, at each extremity of the muscle is formed by a union of the fasciæ that surrounds the fibres as well as the muscle. These tendons are attached to the periosteum, or covering of the bone. (Fig. 89.)

Q. How are the tendons formed? To what are they attached?

Fig. 89.

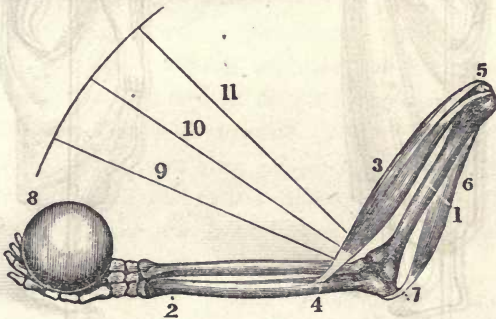


Fig. 89. A representation of the manner in which all the joints of the body are moved. 1. The bone of the arm above the elbow. 2. One of the bones below the elbow. 3. The muscle that bends the elbow. This muscle is united, by a tendon, to the bone below the elbow, (4;) at the other extremity, to the bone above the elbow, (5.) 6. The muscle that extends the elbow. 7. Its attachment to the point of the elbow. 8. A weight in the hand to be raised. The central part of the muscle, (3,) contracts, and its two ends are brought nearer together. The bones below the elbow are brought to the lines shown by 9, 10, 11. The weight is raised in the direction of the curved line. When the muscle 6 contracts, the muscle 3 relaxes and the fore arm is extended.

274. The tendon at one end of a muscle is attached to

the covering of a bone, while the tendon of the opposite

Fig. 90.



Fig. 91.

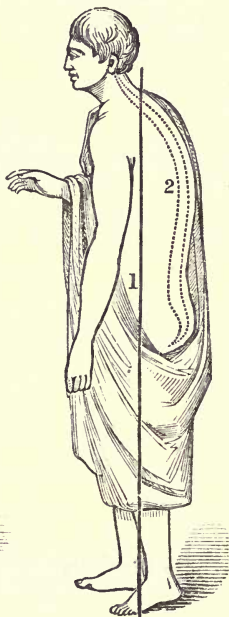


Fig. 90. 1. A perpendicular line from the centre of the feet to the upper extremity of the spinal column, where the head rests. 2, 2, 2. The spinal column, with its three natural curves. Here the head and body are balanced upon the spinal column and joints of the lower extremities, so that the muscles are not kept in a state of tension. This erect position of the body and head is always accompanied with straight lower limbs.

Fig. 91. 1. A perpendicular line from the centre of the feet. 2 Represents the unnatural curved spinal column and its relative position to the perpendicular, (1.) The lower limbs are curved at the knee, and the body is stooping forward. While standing in this position, the muscles of the lower limbs and back are in continued tension, which exhausts and weakens them.

end is fixed to the covering of another bone. (Fig. 89.)

Q. How are the tendons attached to bones ?

275. By the contraction of the fibres of the muscle, the position of one of the bones is changed. (Fig. 89.)

Q. How is the position of bones changed ?

276. All the movements of the body are made by the muscles contracting.

Q. How are the movements of the body made ?

277. The INVOLUNTARY movements are those we cannot control — as of the ribs when we breathe.

Q. What are involuntary movements ?

278. The VOLUNTARY movements are under the control of the will — as walking, nodding the head, swinging the arms, and others done at our pleasure.

Q. What are voluntary movements ?

279. In standing, walking, or sitting, the erect position is the best, as well as the easiest. Care should be taken that the position is frequently varied, particularly in children. (Figs. 90, 91.)

Q. What position is best ? What care should be exercised ?

REVIEW.

270, 271, 272, 273, 274.	<i>Anatomy</i>	} of the MUSCLES.
268, 269, 275, 276, 277, 278.	<i>Physiology</i>	
279.	<i>Hygiene</i>	

Review by Questions. — Of what are muscles composed ? What can you say of the fibres ? of the fasciæ ? of the tendons ? of the contraction and relaxation of muscles ? of the movements of the body ? of involuntary movements ? of voluntary movements ? What is said of position in standing, writing, and sitting ?

REVIEW BY TOPICS. — Give the Anatomy of the muscles, the Physiology, the Hygiene. (See outline anatomical, Plates III. and IV.)

LESSON XXVI.

280. When muscles are used certain conditions should exist, so that their action may not only be energetic and controllable, but healthy. Some of these conditions will be suggested in this lesson.

Q. What is the subject of this lesson ?

MUSCLES, (CONTINUED.)

281. When MUSCLES have been used they become tired or exhausted, and need rest or relaxation. The recesses in school rest the muscles of the pupil, because the position is, or should be, changed.

Q. Why do the used muscles need rest ? What is said of recesses in schools ?

Remark. — Young and feeble persons require more frequent change of position than old and strong persons. This is particularly true with children, if growing rapidly.

Q. What persons need the most frequent change of position ?

282. The COLOR of a muscle depends upon the color of the blood. If that is white, the color of the muscle is white. If it is red, the color of the muscle is red.

Q. Upon what does the color of a muscle depend ?

283. PURE BLOOD is essential to the health and strength of a muscle. If the air of a room is impure, the blood becomes impure ; consequently the muscles are soon exhausted, and we feel restless.

Q. What is necessary to the health and strength of a muscle ? What condition of the blood causes exhaustion and restlessness ?

Remark. — The restlessness of children in a school room may be diminished or removed by ventilating the room.

Q. How can the restlessness of children in the school room be diminished ?

Fig. 92.

Fig. 93.



Fig. 92. An improper, but not an unusual, position when writing.

Fig. 93. A proper position when writing.

284. The muscles should be *gradually* called into use, if we do not wish to weary them too soon. This remark should not be forgotten in driving horses and other animals.

Q. How should we use the muscles ? What remark in reference to driving animals ?

285. After hard work or severe exercise, the muscles should be rested *gradually* and the skin thoroughly washed or rubbed. This principle also applies to horses.

(See p. 120.)

Fig. 94.

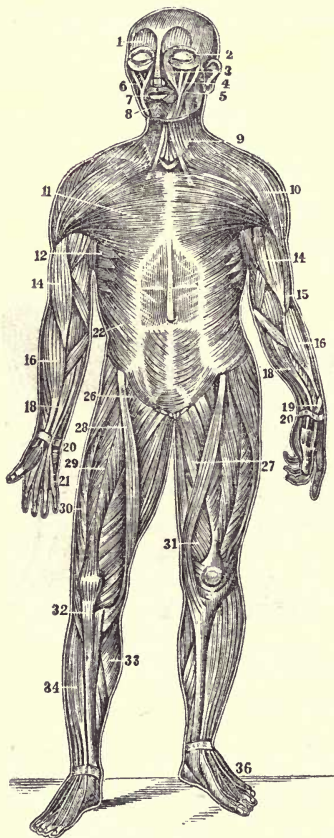


Fig. E.

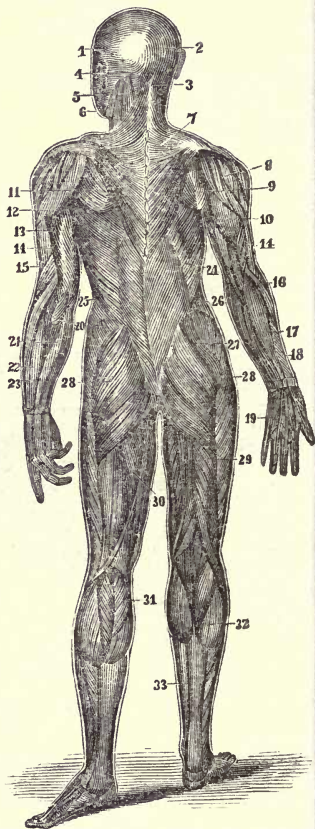


Fig. 94. A front view of the muscles. 1, 2, 3, 4, 5, 6, 7, 8. Muscles of the head and face. 9. Muscles of the neck. 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20. Muscles of upper extremities. 22. Muscles of the body. 26, 27, 28, 29, 30, 31, 32, 33, 34, 36. Muscles of lower extremities.

Fig. E. A back view of the muscles of the body. 1, 2, 3, 4, 5, 6, 7. Muscles of the head and neck. 8, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 43. Muscles of the upper extremities. 9, 11, 12, 24, 25, 26. Muscles of the body. 27, 28, 29, 30, 31, 32, 33. Muscles of the lower extremities.

Practical Explanation. The muscle 1, fig. 94, by its contraction, raises the eyebrows. The muscle 2, fig. 94, closes the eyelids. The muscle 3, fig. 94, elevates the upper lip. The muscles 4, 5, fig. 94, elevate the angles of the mouth. The muscles 6, fig. 94, and 5, fig. E, bring the teeth together. The muscle 7, fig. 94, closes the mouth. The muscle 8, fig. 94, depresses the lower lip. The muscles 9, fig. 94, and 6, fig. E, bend the neck forward. The muscles 3, 4, fig. E, elevate the head and chin. The muscle 22, fig. 94, bends the body forward, and draws the ribs downward. The muscle 11, fig. 94, brings the shoulder forward. The muscle 7, fig. E, draws the shoulder back. The muscles 10, fig. 94, and 8, fig. E, elevate the arm. The muscles 11, fig. 94, and 24, fig. E, bring the arm to the side. The muscle 14, fig. 94, bends the arm at the elbow. The muscle 10, fig. E, extends the arm at the elbow. The muscles 16, 18, fig. 94, bend the wrist and fingers. The muscle 19 bends the fingers. The muscles 18, 21, 23, fig. E, extend the wrist. The muscle 23, fig. E, extends the fingers. The muscles 26, 27, 28, fig. 94, bend the lower limbs on the body, at the hip. The muscle 28, fig. 94, draws one leg over the other, (the position of a tailor when sewing.) The muscles 27, 28, fig. E, extend the lower limbs on the body, at the hip. The muscles 29, 30, 31, fig. 94, extend the leg at the knee. The muscles 29, 30, fig. E, bend the leg at the knee. The muscles 34, 36, fig. 94, bend the foot at the ankle, and extend the toes. The muscles 31, 32, 33, fig. E, extend the foot at the ankle.

SYNTHETIC REVIEW OF THE MUSCULAR SYSTEM.

270, 271, 272, 273, 274.	Muscles,	}	ANATOMY	} of the MUSCULAR SYSTEM. (Fig. 94.)	
	Muscles, continued,				
268, 269, 275, 276, 277,	} Muscles,	}	PHYSIOLOGY		
278.					
281, 282, 283. . . .	Muscles, continued,	}	HYGIENE		
279.	Muscles,				
281, 282, 283, 284, 285,	} Muscles, continued,	}	HYGIENE		
286, 287, 288. . . .					

Review by Questions. — What can you tell of a muscle? of its fascia? of its fibres? of its tendons? of the attachment of tendons to bones?

What can you state of the contraction of a muscle? of its relaxation? What are voluntary movements? involuntary movements?

What can you say of position? of rest? What should be the quality of the blood in muscles? How should muscles be called into action? how rested? How used to prevent disease? How is skilful motion attained?

REVIEW BY TOPICS. — Give the Anatomy of the muscles, the Physiology, the Hygiene. (Use outline anatomical, Plates III. and IV.)

Q. How should the muscles be rested and skin treated after severe exercise? How with horses?

Remark. — Rheumatism and other painful diseases of the fasciæ and tendons of the muscles, as well as the periosteum and ligaments of bones, are caused by sitting in a current of air after severe exercise of the muscles.

Q. What will cause rheumatism?

286. SKILFUL MOTION is attained by the proper training or education of the muscles. The more correct the training of the muscles in childhood, the more graceful are the movements in adult age.

Q. How is skilful motion acquired? How are graceful movements in adults attained?

287. In teaching writing, not only the position of the pen and the form of the letter should be noticed, but the position of the body, head, and arm should be correct. (Figs. 92, 93.)

Q. What is said relative to writing?

288. There is a constant change in the substance of muscle when used. The wornout atoms of matter are removed and returned to the heart in the blood, while new atoms are supplied through the blood as it comes from the heart. (Figs. 28, 29, 39, 40, 42.)

Q. What is said of the change of muscles when used? How is the wornout matter removed? How is new matter supplied?

REVIEW.

281, 282, 283.	<i>Anatomy</i>	} of the MUSCLES.
281, 282, 283, 284, 285, 286, 287, 288. .	<i>Physiology</i>	
	<i>Hygiene</i>	

Review by Questions. — How should muscles be used? Upon what does the color of a muscle depend? What is said of the blood of a muscle? How should muscles be called into action? How should muscles be rested? How is skilful motion attained? What is said of writing?

REVIEW BY TOPICS. — Give the Anatomy of this lesson, the Physiology the Hygiene. (See anatomical Plates III. and IV.) REVIEW LESSON, page 118.

CHAPTER III.

289. IN this chapter we shall treat of the part that is, in a striking manner, a “puller down” of the body. The human system is in a state of constant decay and renovation, and the membrane that covers the animal frame forms one of the principal outlets, or drains, by which the old, altered, or useless atoms of matter escape from the body.

Q. What is said of the membrane that covers the human frame ?

LESSON XXVII.

290. The means of defence in man do not consist in a thick or scaly covering, but in a delicate and sensitive membrane that envelops the body. This is called the *cu'tis*, or skin. It is divided into two layers—the outermost, called the *cu'ti-cle*, (scarf skin;) the inner, called the *cu'tis ve'ra*, (true skin.) (Fig. 95.)

Q. Of how many layers is the skin composed? What are they called ?

THE CUTICLE.*

291. The CUTICLE is a thin membrane. It has no blood vessels or nerves. For this reason, when it is cut

* Illustrate this lesson by experiments, outline plates, and the black-board.

it neither bleeds, nor is there pain felt. It is the layer of the skin that is raised in blisters. (Fig. 95.)

Q. Describe the cuticle. Which layer of the skin is raised in blisters?

Experiment.—To show that the cuticle has no nerves or blood vessels, pass a pin though the portion that skirts the nails, or shave a thin piece from the palm of the hand.

Q. How can you show that the cuticle has no blood vessels or nerves?

Fig. 95.



Fig. 95. 1, 1. The cuticle. 2, 2. The colored layer of the cuticle. 4, 4. The network of nerves. 5, 5. The true skin. 6, 6, 6. Three nerves that divide to form the network.

292. The cuticle contains a chemical substance called *albu-men*. It exists nearly pure in the white of an egg.

Q. What chemical substance does the cuticle contain? Where does it exist nearly pure?

293. Dried albumen is softened by alkali, as soda and soap, but hardened by alcohol or vinegar. Hence

in fevers, or when the skin is dry and inactive, bathe with pure water, or water that contains a small amount of alkali.

Q. How is dried albumen softened? How hardened? What should we bathe with in fevers?

294. The under surface of the cuticle contains the coloring matter of the skin. In the African it is black; in the Indian it is copper colored; in the European it varies with the race. (Fig. 95.)

Q. Where is the coloring matter found that gives the skin its different hues?

295. The cuticle varies in thickness in different parts of the body, from the delicate skin upon the lips to the thick and almost horny covering of the palms of the hands and soles of the feet.

Q. Does the cuticle vary in thickness in different parts of the body?

296. The cuticle is thickened by gradual exercise. This is a kind provision of the Creator, as it affords increased protection to those persons engaged in manual employments.

Q. How is the cuticle thickened? Wherein is the result a kind provision of the Creator?

297. The cuticle, when removed, is formed again by atoms of matter from the blood vessels of the inner layer of the skin. This material is at first quite soft, but gradually hardens so as to shield the highly sensitive layer of the skin.

Q. When the cuticle is removed, how is it reproduced?

Illustration. — The inner bark of a tree is much softer than the outer. In spring the inner parts are nearly fluid.

298. When the cuticle — the natural covering of the nerves of the skin — is removed by burns or scalds, the smarting nerves should be quickly covered with flour or any simple dressing.

Q. What is the natural covering of the nerves of the skin? How should burns be dressed?

299. As God, in his great goodness, has provided *agents* and *material* to renew the cuticle when destroyed, there is no need of “healing salves” and “ointment” to produce “new skin.”

Q. Why do we not need healing salves and ointments?

REVIEW.

291, 292, 293, 294, 295, 296, 297.	<i>Anatomy</i>	} of the CUTICLE.
290, 291, 292, 293, 294, 295, 296, 297.	<i>Physiology</i>	
293, 298, 299.	<i>Hygiene</i>	

Review by Questions. — How is the skin divided? What can you say of the cuticle? of its chemical composition? of its coloring matter? of its thickness? of the means by which it is thickened? How is it renewed when removed? How should burns be treated?

REVIEW BY TOPICS. — Give the Anatomy of the cuticle, the Physiology, the Hygiene. (See outline anatomical, Plate IX.)

LESSON XXVIII.

300. While the structure of the cuticle is in harmony with its use, placed as an insensible covering between external objects and the delicately organized subjacent parts, the inner layer of the skin, on the other hand, is highly sensitive, and the seat of many functions. From the importance of its structure and use it is called *cutis vera*, (true skin.)

Q. Give the comparison between the cuticle and cutis vera.

THE CUTIS VERA.*

301. The CUTIS VERA is more dense than the cuticle.

* Illustrate this lesson by experiments, outline diagrams, and the black-board

It contains *nerves*, *blood vessels*, *per-spi'ra-to-ry glands*, and *ducts*, and *oil glands* and *ducts*. (Figs. 95, 96, 97.)

Q. Describe the cutis. What does it contain?

302. The *nerves* are small, and very abundant, in every part of the skin. Hence we cannot wound the skin in any part without causing pain. (Figs. 95, 96.)

Q. Describe the nerves of the skin.

Remark. — The skin is the most sensitive part of the body. The muscles (lean meat) have but little feeling; while the ligaments, (cords,) bones, and marrow have still less sensibility. Consequently the greatest pain to the patient in surgical operations is in cutting the skin.

Q. What is said in the remark about the sensibility of different parts of the body?

Fig. 96.

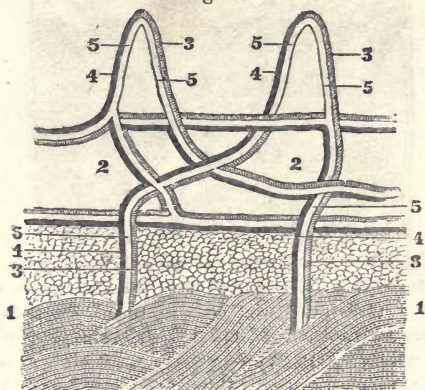


Fig. 96. An ideal representation of the papillæ. 1, 1. The cutis vera. 2, 2. The papillary layer. 3, 3. The arteries of the papillæ. 4, 4. The veins of the papillæ. 5, 5. The nerves of the papillæ.

303. The BLOOD VESSELS are the *arteries* and *veins*

through which the blood flows to and from the skin. These vessels, as well as the nerves, are very abundant. (Fig. 96.)

Q. What is said of the blood vessels of the skin?

304. The PERSPIRATORY GLANDS consist of very small tubes, coiled up in the deeper parts of the true skin. A small duct from each opens upon the external surface of the cuticle. (Figs. 97, 99.)

Q. Of what does the perspiratory glands consist? What is said of the ducts?

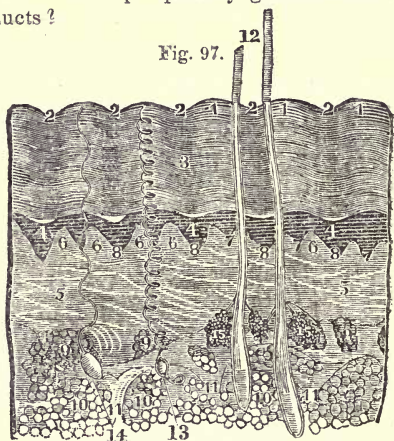


Fig. 97. 1, 1. The lines or ridges of the cuticle, cut perpendicularly. 3. The cuticle. 4, 4, 4. The colored layer of the cuticle. 5, 5. The cutis vera. 9, 9. Cells filled with fat. 10, 10, 10. The adipose layer, with numerous fat vesicles. 11, 11, 11. Cellular fibres of the adipose tissue. 12. Two hairs. 13. A perspiratory gland, with its spiral duct. 14. Another perspiratory gland, with a duct less spiral. 15, 15. Oil glands, with duct opening into the sheath of the hair, (12.)

305. These glands separate from the blood, and convey from the system, daily, from twenty to forty ounces of waste matter. This refuse material passes from the skin in the form of perspiration, or sweat. (Figs. 97, 99.)

Q. What is the use of the perspiratory glands? In what form does the waste matter pass from the skin?

Experiment. — Place the hand in an inverted cold glass jar; in a little time the inner surface of the jar will be covered with moisture. This is the insensible perspiration, condensed by coming in contact with the cold jar.

Q. What experiment shows that the skin is constantly permitting waste matter to escape from the body.

306. The OIL GLANDS are small bodies in the deeper parts of the true skin, from which ducts proceed, that open into the sheath of the hairs and upon the surface of the skin. They separate an oily matter that lodges upon the hair and skin. (Figs. 97, 99.)

Q. Describe the oil glands. What is their use?

307. The waste matter, separated by the perspiratory and oil glands, is composed of water, oil, salt, rust of iron, &c. The water will dry off or evaporate; but the other products of the waste atoms of matter remain upon the skin, forming a kind of varnish. (Figs. 97, 99.)

Q. Of what does the waste matter from the body consist? What becomes of the water? Of the other products of the waste matter?

308. BATHING is necessary to remove the refuse matter from the whole surface of the body. This should be done daily, to secure perfect health of the skin.

Q. Why is bathing necessary? How often should we bathe?

309. The waste matter adheres to the clothing, and also to the bedclothes. Hence, when worn or used, they should be aired daily and frequently changed.

Q. What is said of clothing and bedclothes?

310. The garments, particularly of children, should

be loosely worn, and the quantity should be sufficient to prevent chills.

Q. How should children be clothed?

311. In the morning, and when the body is not tired, we need less clothing than when fatigued or in the evening. At all times wear enough clothing, so that there shall not be felt the slightest chill.

Q. When does the body need the greatest amount of clothing? What general rule in regard to clothing?

REVIEW.

301, 302, 303, 304, 306.	. <i>Anatomy</i>	} of the CUTIS VERA.
302, 303, 305, 306, 307.	. <i>Physiology</i>	
307, 308, 309, 310, 311.	. <i>Hygiene</i>	

Review by Questions. — What does the cutis vera contain? What can you say of its nerves? of its blood vessels? of its perspiratory glands? of its oil glands? Of what is the waste matter composed? How is it separated from the body? What is said of bathing? of bed clothing? of garments for children and others? When should clothing be changed?

REVIEW BY TOPICS. — Give the Anatomy of the cutis vera, the Physiology, the Hygiene. (See outline, Plate IX.)

CHAPTER IV.

312. IN this chapter we shall tell you something of the most curious operation of the human system. It is the wonderful function by which the warmth of the living body is kept nearly uniform. It is called *animal heat*.

Q. What does Chapter IV., Part III., treat of?

ANIMAL HEAT.

313. The HEAT of the human flesh at all seasons of the year, and in all parts of the globe, is nearly the same.

From the River Amazon to the Polar Sea the temperature of the body is about 98°.

Q. What is said of animal heat? What is the average temperature of the body?

314. The heat of the body depends, not upon the air that surrounds it, or the clothing that covers it, but upon the change of atoms of matter that is constantly taking place in the capillary vessels of the human frame.

Q. Upon what does animal heat depend?

315. The wornout atoms of the body are composed, mainly, of *carbon* and *hydrogen*. These, when they unite with the *oxygen* in the blood of the capillary vessels in all parts of the system, produce heat.*

Q. How is heat produced in the body?

Remark.—The burning or combustion of the atoms of matter in the living body is on the same principle as the burning of coal or wood.

Q. What is stated in the remark?

316. The quantity of heat produced in the system is influenced by the state of the mind, the health of the body, the quantity and kind of food, the air we breathe, the amount of exercise, and the kind of clothing.

Q. What influences the quantity of animal heat?

REVIEW.

	<i>Anatomy</i>	} of ANIMAL HEAT.
312, 313, 314, 315. . .	<i>Physiology</i>	
316.	<i>Hygiene</i>	

Review by Questions.—What is said of the heat of the body? How is animal heat produced? What modifies the amount of animal heat?

REVIEW BY TOPICS.—Give the Physiology of animal heat, the Hygiene.

* Let the teacher explain the composition of air, water, food, and blood, and how the three before-mentioned elements enter into the blood vessels of the body.

Fig. 98.

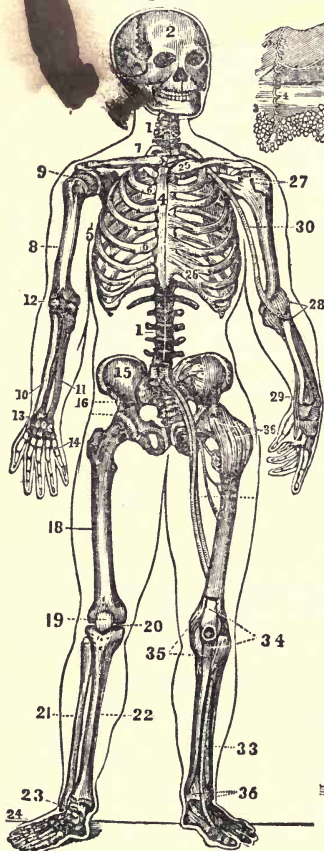


Fig. 99.



Fig. 100.

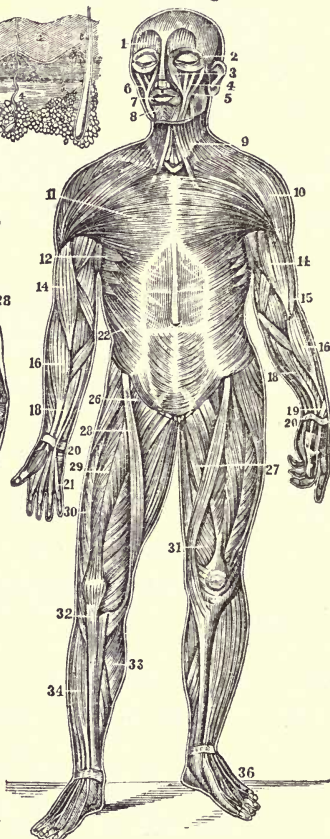


Fig. 98. 1, 1. The spinal column. 2. The skull. 4. The sternum. 5. The ribs. 7. The clavicle. 8. The humerus. 10. The radius. 11. The ulna. 13. The wrist. 14. The hand. 15. The haunch bone. 16. The sacrum. 18. The thigh bone. 19. The patella. 21. The fibula. 22. The tibia. 23. The ankle joint. 24. The foot. 25, 25. The ligaments of the clavicle, sternum, and ribs. 27, 28, 29. The ligaments of the shoulder, elbow, and wrist. 31. The ligaments of the hip joint. 34, 35, 36. The ligaments of the patella, knee, and ankle.

Fig. 99. 1. The cuticle. 2. The cutis vera. 3. The fat below the skin. 4. 4 Perspiratory glands and ducts. 5. Oil glands. 6. A hair

SYNTHETIC REVIEW OF THE HUMAN SYSTEM

Preface,		
Introduction,		
General analysis,		
Teeth,	DIGESTIVE SYSTEM,	NUTRITIVE APPARATUS.
Salivary glands,		
Stomach,		
Small intestine,		
Lacteals,		
Large intestine,		
Synthetic review,		
Thorax,	RESPIRATORY SYSTEM,	NUTRITIVE APPARATUS.
Lungs,		
Pulmonary vessels,		
Air,		
Synthetic review,		
Heart,	CIRCULATORY SYSTEM,	NUTRITIVE APPARATUS.
Pulmonic circulation,		
Systemic circulation,		
Synthetic review,		
Vocal organs,	VOCAL SYSTEM,	NUTRITIVE APPARATUS.
Synthetic review,		
Brain,	CEREBRO SPINAL SYSTEM,	NERVOUS APPARATUS. PROTECTIVE APPARATUS.
Spinal cord and nerves,		
Synthetic review,		
Feeling,	SENTIENT SYSTEM,	NERVOUS APPARATUS. PROTECTIVE APPARATUS.
Taste,		
Smell,		
Seeing,		
Hearing,		
Synthetic review,		
Head,	OSSEOUS SYSTEM,	NERVOUS APPARATUS. PROTECTIVE APPARATUS.
Trunk,		
Upper extremities,		
Lower extremities,		
Composition of bones,		
Joints,		
Synthetic review,		
Muscles,	MUSCULAR SYSTEM,	NERVOUS APPARATUS. PROTECTIVE APPARATUS.
Muscles, continued,		
Synthetic review,		
Cuticle,	CUTANEOUS SYSTEM,	NERVOUS APPARATUS. PROTECTIVE APPARATUS.
Cutis vera,		
Animal heat,		
Synthetic review,		
General synthetic rev.,		



"A HARP
OF A THOUSAND STRINGS."

GENERAL REVIEW BY TOPICS.—Give the Anatomy, Physiology, and Hygiene of the organs, systems, and apparatuses of man. Use outline anatomical plates, make tableaux, and draw illustrating figures upon the blackboard. (See pages 58, 59, 90, 91, 130, 131.)

KEY TO ANATOMICAL OUTLINE PLATES.

SUGGESTIONS TO TEACHERS.

IN using these plates, we would suggest that the pupil carefully examine the illustrating cuts interspersed with the text in connection with the lesson to be recited. The similarity between these and the plates will enable the pupil to recite, and the teacher to conduct, his recitation from the latter.

Let a pupil show the situation of an organ, or part, on an anatomical outline plate, and also give its structure, while other members of the class note all omissions and misstatements. Another pupil may give the use of that organ; and, if necessary, others may give an extended explanation. The third may explain the laws on which the health of the part depends, while other members of the class supply what has been omitted. After thus presenting the subject in the form of topics, questions may be proposed promiscuously from each paragraph; and where examples occur in the text, let other analogous ones be given.

PLATE I.

A FRONT VIEW OF THE SKELETON.

Bones of the Head. 7, The sphenoid bone. 8, The frontal bone. 10, The parietal bone. 11, The os unguis. 12, The superior maxillary bone, (upper jaw.) 13, The nasal bone. 14, The ethmoid bone. 15, The malar bone, (cheek bone.) 16, The vomer. 17, The inferior maxillary bone, (the lower jaw.) *a*, Its body. *b*, Its ramus, or branch. 18, The teeth.

Bones of the Trunk. 1, 1, The spinal column. 2, The sternum. 3, 3, The ribs. 4, The sacrum. 5, The innominatum.

Bones of the Upper Extremities. 19, The clavicle, (collar bone.) 20, The scapula, (shoulder blade.) 21, The humerus. 22, The ulna. 23, The radius. 24, 25, 26, 27, 28, 29, 30, 31, The bones of the carpus, (wrist.) 32, 32, 32, The five bones of the metacarpus, (the palm of the hand.) 33, 33, 33, The first range of finger bones. 34, 34, The second range of finger bones. 35, 35, 35, The third range of finger bones.

Bones of the Lower Extremities. 36, The femur, (thigh bone.) 37, The patella, (knee pan.) 38, The tibia, (shin bone.) 39, The fibula. 40, 40, 40, The bones of the tarsus, (instep.) 41, 41, The bones of the metatarsus, (middle of the foot.) 42, 42, The bones of the toes.

ARTICULATIONS. (Left side of the plate.)

Ligaments of the Trunk. 1, 1, The common spinal ligament. 2, 2, The intervertebral ligament, (cartilage between the vertebræ.) 9, 10, 11, 12, Articulations of the ribs with the spinal column. 13, 13, 14, 15, 16, Ligaments that connect the cartilages of the ribs with the sternum.

Ligaments of the Upper Extremities. 25, The ligament that connects the clavicle and sternum. 27, The ligament that connects the upper rib and clavicle. 28, 29, 30, Ligaments that connect the clavicle and scapula. 31, 32, 33, 34, Ligaments of the shoulder joint. 35, 35, 36, Ligaments of the elbow joint. 37, 38, 39, 40, Ligaments of the wrist. 41, 42, 43, 44, Ligaments of the fingers.

Ligaments of the Lower Extremities. 49, 49, Ligaments of the hip joint. 50, 50, Ligaments of the patella. 51, 52, 53, 54, 55, Ligaments of the knee joint. 56, A large bursa mucosa. 57, The ligament of the tibia and fibula. 58, 58, The interosseous ligament. 59, 59, Ligaments of the ankle joint. 60, 61, 62, Ligaments of the metatarsus. 63, 64, Ligaments of the toes.

A, The brachial artery. B, The brachial vein. C, The radial artery. D, The femoral artery. E, The femoral vein. F, G, The anterior tibial artery.

PLATE II.

A BACK VIEW OF THE SKELETON.

Bones of the Head. 5, The occipital bone. 6, The parietal bone. 7, The temporal bone. 8, The frontal bone. 9, The sphenoid bone. 15, The malar bone. 16, The nasal bone. 17, The superior maxillary bone, (upper jaw.) 18, The inferior maxillary bone, (lower jaw.) 19, The teeth.

Bones of the Trunk. 1, 1, The spinal column. 2, The sacrum. 3, The coccyx. 20, The innominatum. 4, 4, The ribs.

Bones of the Upper Extremities. 21, The clavicle, (collar bone.) 22, The scapula, (shoulder blade.) 23, The humerus. 24, The ulna. 25, The radius. 26, 27, 28, 29, 30, 31, 32, The bones of the carpus, (wrist.) 33, 33, 33, The bones of the metacarpus, (palm of the hand.) 34, 34, 34, The first range of finger bones. 35, 35, The second range of finger bones. 36, 36, 36, The third range of finger bones.

Bones of the Lower Extremities. 37, The femur, (thigh bone.) 38, The patella, (knee pan.) 39, The tibia, (shin bone.) 40, The fibula. 41, 42, 43, 44, 45, The bones of the tarsus, (instep.) 46, 46, The bones of the metatarsus, (middle of the foot.) 47, 47, Bones of the toes.

ARTICULATIONS. (Left side of the plate.)

Ligaments of the Trunk. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Ligaments of the spinal column. 14, 14, 15, 15, Ligaments that connect the ribs and spinal column. 11, 11, 21, 22, 23, 24, 25, 26, Ligaments that connect the sacrum and innominatum.

Ligaments of the Upper Extremities. 27, 28, Ligaments that connect the clavicle and scapula. 29, The capsular ligament of the shoulder joint.

30, 30, Ligaments of the elbow. 31, 32, 33, 34, Ligaments of the carpus, (wrist.)

Ligaments of the Lower Extremities. 9, Tendon of the gluteus muscle. 35, The capsular ligament of the hip joint. 36, 36, Ligaments of the knee joint. 37, The ligament that connects the tibia and fibula. 38, The interosseous ligament. 39, 40, Ligaments of the ankle joint.

PLATE III.

A FRONT VIEW OF THE MUSCLES.

Muscles of the Head and Neck. 7, The sterno-mastoideus muscle. 8, The sterno-hyoideus muscle. 9, The omo-hyoideus muscle. 10, The trapezius muscle. 11, The orbicularis oculi muscle. 12, The frontal muscle. 14, The orbicularis oris muscle. 15, The elevator muscle of the nostrils. 16, The zygomatic muscle. 17, The depressor of the lower lip. 18, The depressor anguli oris muscle. 19, The triangular muscle of the nose. 20, 21, The aural muscles. 22, The masseter muscle.

Muscles of the Trunk. 2, 3, The external oblique muscles.

Muscles of the Upper Extremities. 1, The grand pectoral muscle. 3, 4, The serratus muscle. 23, The deltoid muscle. 24, The biceps brachialis muscle. 25, The coraco-brachialis muscle. 26, The anterior brachial muscle. 27, The triceps brachialis muscle. 28, The long supinator muscle. 29, The external radial muscle. 30, The pronator teres muscle. 31, The anterior radial muscle. 32, The palmaris brevis muscle. 33, The anterior ulnar muscle. 35, The palmar muscle. 36, The abductor muscle of the thumb. 37, The adductor muscle of the thumb. 38, 39, Small flexor muscles of the thumb. 40, The abductor muscle of the little finger. 41, 41, The lumbricales muscles. 61, 61, The bifurcation of the tendons of the superficial flexor muscle in the fingers.

Muscles of the Lower Extremities. 42, The fascia lata muscle. 43, The sartorius muscle. 44, The rectus femoris muscle. 45, The vastus externus muscle. 46, The vastus internus muscle. 47, The internal straight muscle. 48, The pectineus muscle. 49, The adductor muscle. 50, The psoas muscle. 51, The tibialis anticus muscle. 52, The long extensor muscle of the great toe. 53, The long extensor muscle of the toes. 54, The anterior peroneal muscle. 55, The long lateral peroneal muscle. 56, 57, The gastrocnemii muscles. 58, The long flexor muscle of the great toe. 59, The short extensor muscles of the toes. 60, The abductor muscle of the great toe.

The figures and letters on the left side of the plate indicate the position of important fasciæ that cover the muscles and enclose the tendons.

PLATE IV.

A BACK VIEW OF THE MUSCLES.

Muscles of the Head and Neck. 4, The sterno-mastoideus muscle. 5, The

complexus muscle. 6, The mylo-hyoideus muscle. 7, 8, The occipito-frontalis muscle. 9, The masseter muscle. 10, 11, 12, The anterior, middle, and posterior aural muscles. 13, The temporal muscle.

Muscles of the Trunk. 1, 1, The trapezius muscle. 2, The latissimus dorsi muscle. 3, The rhomboideus muscle. 4, The external oblique muscle.

Muscles of the Upper Extremities. 5, The deltoid muscle. 6, 7, The infra-spinatus muscle. 9, The triceps extensor muscle. 10, The internal brachial muscle. 11, The long supinator muscle. 12, The external radial muscle. 13, The second external radial muscle. 14, The anconeus muscle. 15, 16, The extensor digitorum communis muscle. 17, The extensor carpi ulnaris muscle. 18, The flexor carpi ulnaris. 19, 20, The extensor ossis metacarpi pollicis muscles. 21, An extensor muscle of the thumb. 22, 28, Interossei muscles.

Muscles of the Lower Extremities. 29, The gluteus maximus muscle. 30, The gluteus medius muscle. 31, The biceps flexor cruris muscle. 32, The semi-tendinosus muscle. 33, The semi-membranosus muscle. 34, The gracilis muscle. 35, The adductor muscle. 36, The vastus externus muscle. 37, The sartorius muscle. 38, 39, The gastrocnemii muscles. 40, The long peroneal muscle. 41, The external peroneal muscle. 42, The long flexor muscle of the great toe. 43, The long extensor muscle of the toes. 44, The short extensor muscle of the toes. 47, The short flexor muscle of the toes.

The figures and letters on the left side of the plate indicate the position of membranous fasciæ which envelop the muscles and tendons.

PLATE V.

ORGANS OF THE THORAX AND ABDOMEN.

Fig. 1. *The Mouth and Neck.* (A side view.) 1, The upper lip. 2, The lower lip. 3, The upper jaw. 4, The lower jaw. 5, The tongue. 6, The hard palate, (roof of the mouth.) 7, The parotid gland. 8, The sublingual gland. T, The larynx. 10, The pharynx. 11, The œsophagus. 12, The upper portion of the spinal column. C, The spinal cord.

The Chest and its Organs. 9, 9, The trachea. R, The right auricle of the heart. L, The left auricle. 13, The left ventricle of the heart. 14, The right ventricle. 15, The aorta. 16, The pulmonary artery. 17, The vena cava descendens. 18, The right subclavian vein. 19, The left subclavian vein. 20, The right jugular vein. 21, The left jugular vein. 22, The right carotid artery. 23, The left carotid artery. 24, 25, 26, The upper, middle, and lower lobes of the right lung. 27, 28, The upper and lower lobes of the left lung. 29, 29, 29, The diaphragm. P, P, P, P, The pleura, that lines the cavity of the chest. S, S, The clavicles. O, O, O, O, The ribs. M, M, M, M, Muscles of the chest. 40, The thoracic duct, opening into the left subclavian vein.

The Abdomen and its Organs. 30, The stomach. 31, 32, The right and left lobe of the liver. F, The fissure that separates the two lobes. 33,

The gall bladder. 34, 34, The duodenum. 35, The ascending colon. 36, The transverse colon. 37, The descending colon. 38, 38, 38, 38, The small intestine. 39, 39, The walls of the abdominal cavity turned down. 41, The spleen.

Fig. 2. *The Relation of the Lacteals and Thoracic Duct.* 1, 1, A section of the small intestine. 2, 2, 2, 2, 2, 2, 2, 2, Mesenteric glands, through which the lacteals from the intestine pass. 3, Several lacteal vessels entering the enlarged portion and commencement of the thoracic duct. 5, 5, 5, The thoracic duct. 6, The thoracic duct opening into the left subclavian vein. 7, (See 40, Fig. 1.) 8, The right subclavian vein. 9, The vena cava descendens. 10, 11, 11, The aorta. 12, The carotid arteries. 13, 13, The jugular veins. 14, The vena azagos. 15, 15, The spinal column. 16, The diaphragm.

Fig. 3. *The Relation of the Larynx, Trachea, Bronchia, and Air Cells.* 1, 1, 1, An outline of the right lung. 2, 2, 2, An outline of the left lung. 3, The larynx. 4, The trachea. 5, The right bronchia. 6, The left bronchia. 7, 7, 7, 7, Divisions of the right bronchia. 8, 8, 8, 8, Divisions of the left bronchia. 9, 9, 9, 9, 9, 9, Air cells.

Fig. 4. *An ideal View of a lateral and vertical Section of the Larynx.* 1, 1, The superior vocal cords, (ligaments.) 2, 2, The inferior vocal cords. 3, 3, The glottis. 4, 4, The ventricles of the larynx.

PLATE VI.

HEART, ARTERIES, AND VEINS.

Fig. 1. *The Heart and large Arteries.* 1, The right auricle of the heart. 2, The right ventricle of the heart. 3, The left auricle. 4, The left ventricle. 5, The pulmonary artery. 6, the aorta. 7, 7, The descending aorta. 8, The arteria innominata. 9, The left carotid artery. 10, The left subclavian artery. 56, The right subclavian artery.

Arteries of the Neck and Head. 15, The right carotid artery. 16, The left carotid artery. 17, The right temporal artery. 50, The right facial artery. 54, The left temporal artery.

Arteries of the Upper Extremities. 11, 11, The left brachial artery. 12, The left radial artery. 13, 13, The right brachial artery. 14, The right radial artery. 51, The right ulnar artery.

Arteries of the Lower Extremities. 18, The left iliac artery. 19, The right iliac artery. 20, The left femoral artery. 21, The right femoral artery. 22, The peroneal artery. 23, The left anterior tibial artery. 24, The muscular artery. 25, 25, The right and left arteria profunda. 26, The right anterior tibial artery. 27, The right peroneal artery.

The Veins of the Neck and Head. 28, The vena cava descendens. 29, The left subclavian vein. 30, The right subclavian vein. 31, The right jugular vein. 32, The left jugular vein. 53, The right temporal vein. 55, The left temporal vein. 49, the right facial vein.

Veins of the Upper Extremities. 33, The left brachial vein. 34, The left

radial vein. 35, The right brachial vein. 36, The right radial vein. 51, The right ulnar vein.

Veins of the Lower Extremities. 37, The vena cava ascendens. 38, The left iliac vein. 39, The right iliac vein. 40, The left femoral vein. 41, The right femoral vein. 42, The left anterior tibial vein. 43, The left peroneal vein. 44, The right anterior tibial vein. 45, The right peroneal vein. 46, 46, The profunda veins. 47, The muscular veins. 48, 48, 48, 48, 48, 48, Intercostal arteries and veins.

Fig. 2. *The Relation of the Cavities of the Heart to the large Blood Vessels.* 1, The vena cava descendens. 2, The vena cava ascendens. 3, The right auricle of the heart. 4, The opening between the right auricle and right ventricle. 5, The right ventricle. 6, The tricuspid valves. 7, The pulmonary artery. 8, 8, The branches of the pulmonary artery that pass to the right and left lung. 9, The semilunar valves of the pulmonary artery. 10, The left pulmonary veins. 11, The right pulmonary veins. 12, The left auricle. 13, The opening between the left auricle and left ventricle. 14, The left ventricle. 15, The mitral valves. 16, 16, The aorta. 17, The semilunar valves of the aorta. 18, The septum between the right and left ventricle.

Fig. 3. *An ideal View of the Heart, Arteries, and Veins.* A, The right auricle. B, The right ventricle. C, The tricuspid valves. D, The opening between the right auricle and right ventricle. E, the left auricle. F, The left ventricle. G, The mitral valves. H, The opening between the left auricle and left ventricle. I, The septum between the right and left ventricle. K, The pulmonary artery. L, The semilunar valves of the pulmonary artery. M, M, The right pulmonary artery. N, N, The left pulmonary artery. O, O, O, O, O, O, The capillary vessels of the lungs. P, P, P, The right pulmonary vein. Q, Q, The left pulmonary vein. R, R, The aorta. S, The semilunar valves of the aorta. T, T, A branch of the aorta to the upper extremities. U, U, U, U, A branch to the lower extremities. V, V, V, V, V, V, The capillary vessels at the extremity of the branches of the aorta. W, W, The descending vena cava. X, X, X, The ascending vena cava.

In Figs. 1, 2, 3, the course of the blood through the circulatory vessels is indicated by arrows.

PLATE VII.

THE PULMONARY CIRCULATION.

Fig. 1. 1, The right auricle of the heart. 2, The left auricle. 3, The right ventricle of the heart. 4, The left ventricle. 5, The pulmonary artery. 6, The branch of the pulmonary artery to the left lung. 7, The branch of the pulmonary artery to the right lung. 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, Branches of the pulmonary artery in the right and left lung. 9, 9, 9, 9, 9, 9, Air cells. 10, 10, 10, 10, 10, 10, 10, Small pulmonary veins in the right and left lung. 11, The left pulmonary vein. 12, 12, The right pulmonary vein.

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Fig. 3. *An ideal View of the Capillaries.* 1, 1, A branch of the pulmonary artery. 2, 2, A branch of the pulmonary vein. 3, 3, Capillary vessels between the artery and vein.

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PLATE VIII.

THE CEREBRUM, CEREBELLUM, SPINAL CORD, AND NERVES.

1, The cerebrum. 2, The cerebellum. 3, 3, The spinal cord. 4, The brachial plexus of nerves. 5, The lumbar plexus of nerves. 6, The sacral plexus of nerves. 7, The facial nerve. 8, 17, The radial nerve. 9, 9, 16, The ulnar nerve. 10, The median nerve. G, The circumflex nerve of the shoulder.

11, 11, The great sciatic nerve. 12, The external popliteal, or peroneal, nerve. 13, 13, The posterior tibial nerve. 14, The external tibial nerve. 15, The muscular branch of the external peroneal nerve. 18, The muscular branch of the sciatic nerve. P, Q, The posterior tibial nerve.

The letters and other figures indicate minor nervous filaments distributed to the various muscles and the skin.

PLATE IX.

THE SKIN.

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Fig. 2. *A Papilla of the Skin.* 1, 1, Two papillæ, formed of an artery, vein, and nerve. 2, 2, 2, Nerves forming a loop in the papillæ. 3, 3, Arteries of the papillæ. 4, 4, Veins of the papillæ. 5, 5, A network of

arteries, veins, and nerves. 6, 6, Nerves of the skin. 8, 8, Arteries of the skin. 7, 7, Veins of the skin.

Fig. 3. *A Hair, and its Oil Glands.* 1, 1, The hair. 2, 2, The sheath of the hair. 3, Oil glands that surround the bulb of the hair, the ducts of which open into the sheath of the hair, (2, 2.)

Fig. 4. *A Section of the Skin.* 1, 1, The cuticle. 2, 2, Its colored portion. 3, 3, The papillary layer. 4, 4, A network of arteries, veins, and nerves upon the upper surface of the cutis vera. 5, 5, 5, 5, The cutis vera, (true skin.) 6, 6, 6, Hairs that originate in the cutis vera. 7, 7, 7, Oil glands, the ducts of which connect with the sheath of the hair. 8, 8, 8, 8, 8, 8, 8, Perspiratory glands and their ducts. 9, 9, 9, 9, 9, Nerves of the skin. 10, 10, 10, 10, 10, Arteries of the skin. 11, 11, 11, 11, 11, Veins of the skin. 12, 12, 12, 12, Papillæ, or ridges of the skin.

PLATE X.

AN ANTERO-POSTERIOR SECTION OF THE EYE.

Fig. 1. 1, 1, The sclerotic coat. 2, 2, The cornea. 3, 3, The choroid coat. 4, 4, The retina. 5, 5, The iris. 6, 6, The posterior chamber of the eye that contains the aqueous humor. 7, 7, The anterior chamber. 8, 8, The pupil. 9, The crystalline humor. 10, 10, The vitreous humor. 11, The optic nerve. 12, A representation of a pen. 13, An inverted image of the pen (12) on the retina. 14, 14, A canal surrounding the crystalline humor. 15, 15, The bevelled junction of the cornea and sclerotic coats. A, A perpendicular ray of light from the pen. B, B, Oblique rays that are refracted in passing through the humors of the eye.

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